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Dynamic Response to Foreign Transfers and Terms-of-Trade Shocks in Open Economies

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and
Luis Serven

Both permanent *and* transitory disturbances can change long-run capacity and output — although they may have opposite effects on the current account. Liquidity constraints and wage rigidities tend to amplify the cyclical adjustment to external shocks.

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This paper — a product of the Transition and Macro-Adjustment Division, Country Economics Department — is part of a larger effort in the department to understand macroeconomic adjustment in developing countries. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Anna Maranon, room N11-039, extension 39074 (December 1992, 46 pages).

The transmission of shocks and policy changes depends crucially on the structure of the economy. Schmidt-Hebbel and Serven analyze the impact of two classes of external shocks in open economies, using a rational-expectations framework that nests three prototype economies:

- A neoclassical, full-employment benchmark economy, with intertemporally optimizing consumers and firms and instantaneous clearing of asset, goods, and factor markets.

- A full-employment economy, with partly liquidity-constrained consumers and investors.

- A Keynesian economy exhibiting both liquidity constraints and wage rigidity, which results in transitory unemployment.

Their model is forward-looking in that the short-run equilibrium of the economy depends on current and expected future values of all exogenous variables, and displays hysteresis (that is, its long-run equilibrium is path-dependent).

Using parameters for a representative open economy, they simulate and compare the dynamic effects of foreign transfers and of a terms-of-trade windfall in the form of a lower price for an imported production input. They contrast the role of Keynesian elements with the neoclassical factors in determining the dynamic adjustment to shocks, by analyzing the effects of permanent/transitory and anticipated/unanticipated disturbances in the three prototype economies. The results illustrate three main points:

- Both permanent *and* transitory disturbances cause changes in long-run capacity and output.

- Transitory and permanent shocks may have opposite effects on the current account; in particular, a permanent favorable foreign shock produces a current account *deficit*, while a transitory favorable shock induces a current account surplus.

- Liquidity constraints and wage rigidities tend to amplify the cyclical adjustment to external shocks.

DYNAMIC RESPONSE TO FOREIGN TRANSFERS AND TERMS-OF-TRADE SHOCKS IN OPEN ECONOMIES*

by

Klaus Schmidt-Hebbel and Luis Serven

The World Bank

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<u>TABLE OF CONTENTS</u>

1. INTRODUCTION

> "Despite the increased attention that macroeconomic management in developing countries has received during the past decade, no consensus has emerged on the appropriate framework for the study of developing country macroeconomic issues ... This lack of consensus ... is even more pronounced at the empirical level" (Haque, Lahiri, and Montiel, 1990).

The current outlook of the developing world is rather mixed. High growth and stable macroeconomic balances characterize the economies of old and new East Asian tigers. A return to foreign financing flows, significant real exchange rate appreciations, and booming stock markets are observed in many highly-indebted countries, with some of them leaving this category as they overcome the debt problem that haunted them for the last decade. Other developing and former socialist economies are barely initiating ambitious stabilization and structural reform programs, whose short-term costs exceed most forecasts. Finally, a number of developing economies -- many in Sub-Saharan Africa -- face stagnation as a result of depleted resource bases, external shocks, and/or massive domestic mismanagement.

While this paper is far from offering a comprehensive assessment of the various "challenges of development" faced by these country groups[1], its more limited objective is to analyze some of the macro management issues faced by most of them. For this purpose the paper develops a small open economy model and applies it to assess the orders of magnitude of the effects of two frequently analyzed external shocks.

As the opening quotation states, a bewildering variety of macroeconomic tools is available to macroeconomic policy makers and analysts. The model developed here forms part of a small but growing sub-family of macroeconomic frameworks which, while firmly based on microanalytic foundations, introduce critical real-world features -- such as short-run wage rigidities and liquidity constraints -- which generate persistent deviations from the frictionless full-employment outcome of the unconstrained neoclassical paradigm. The dynamic general equilibrium model developed here nests as special cases the classical and Neo-Keynesian benchmarks, and assumes rational-expectation formation. Hence short-term equilibria depend on current and anticipated future trajectories of policy and external variables.

Forward-looking behavior based on microanalytical foundations is a feature that this paper shares with an increasing number of recent models applied to open-economy issues such as oil shocks, interest rate changes or policy coordination in multi-country frameworks (Sachs, 1983, Giavazzi et.al., 1982, Lipton and Sachs 1983, Bruno and Sachs 1985, McKibbin and Sachs 1989). Nesting of classical and Keynesian benchmarks characterizes also the model by McKibbin and Sachs (1989), although they do not discuss its implications for the response of the economy to shocks. This paper extends previous work in two dimensions. First it extends the analytical structure by incorporating simultaneously several realistic features that are particularly relevant for developing countries: nominal rigidities, monetary finance of budget deficits, import content of capital goods, foreign holdings of domestic equity, and public investment. Second, it explores in some detail the short- and long-term consequences of liquidity constraints affecting private consumption and investment behavior. The analysis is based on the comparison of the differential effects of external shocks under Keynesian and neoclassical benchmarks, both for permanent/transitory and anticipated/unanticipated disturbances.

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[1] See the 1991 World Development Report under this title (World Bank, 1991) for a comprehensive treatment of current development issues.

The paper is organized as follows. Section 2 spells out the model structure, which is based on the distinction of the domestic private sector (households and firms), the consolidated public sector, and the external sector. The private sector comprises one group of intertemporally-optimizing agents with another of liquidity-constrained (or myopic) agents. The domestic economy produces one single good, while the rest of the world produces both an intermediate input and a final good; the three goods are imperfect substitutes. The asset menu distinguishes between foreign and domestic bonds, domestic equity, and domestic money. Asset markets, as well as the domestic goods market, are assumed to clear instantly. In contrast, the labor market can display real and/or nominal wage inertia, giving rise to persistent deviations from full employment.

Section 3 describes the steady state and the stability properties of the economy. The dynamics of the model are characterized by the combination of backward-looking dynamic equations describing the time paths of predetermined variables (asset stocks, as well as the real wage), and forward-looking equations describing the trajectory of asset prices. The model displays hysteresis and thus its steady state is path-dependent: it is affected by the initial conditions and the entire adjustment path followed by the economy in response to a shock. Transitory disturbances can therefore have permanent effects, whose magnitude depends on key parameters determining the speed of adjustment of the system. The numerical solution of the model poses a two-point boundary-value problem.

Section 4 presents simulation results for two favorable external shocks: a unilateral foreign transfer and a rise in the external terms of trade, brought about by a decline in the world price of an intermediate input (say an oil price windfall in the case of an oil-impoting economy). The section discusses and compares the effects of the two shock classes on the dynamic pattern of the main endogenous variables, for different combinations of structural benchmarks (neo-classical, liquidity constraints with full employment, and liquidity constraints with unemployment) and shock types (permanent, transitory unanticipated and transitory anticipated). Section 5 closes the paper with some concluding remarks.

2. THE MODEL

The basic features of the model represent a compromise between theoretical rigor, real-world relevance, and model implementation costs. The domestic economy produces one single final good, which can be used for consumption and investment at home, or sold abroad. The domestic good is an imperfect substitute for the foreign final good, and its production requires the use of an imported intermediate input.

Domestic private agents hold four assets: money, domestic debt issued by the consolidated public sector (i.e., the government plus the central bank), foreign assets and equity claims on the domestic capital stock. Money allows for inflationary finance of budget deficits. In the absence of risk and uncertainty, all non-monetary assets are assumed to be perfect substitutes, and there are no restrictions to capital mobility. Hence their respective anticipated returns satisfy the corresponding uncovered parity conditions. Foreigners hold domestic equity but not domestic public debt. Finally, the public sector also holds foreign assets.[2]

Both goods and asset markets clear continuously. Equality between demand and supply of the domestic goods determines the real exchange rate. Under a flexible nominal exchange rate regime, money market equilibrium with an exogenously set money supply determines the nominal exchange rate. In

[2] Foreign assets held by the domestic private and public sectors are net assets (equal to gross foreign reserves plus other gross foreign assets less gross foreign liabilities) and therefore can have either sign.

contrast, the labor market may not clear instantaneously due to real and/or nominal wage rigidity. Wages are indexed to current and past consumer price inflation, and react slowly to deviations from full employment.

The dynamics of the model arise from two basic sources: the accumulation of assets/liabilities, dictated by stock-flow consistency of the sectoral budget constraints, and the forward-looking behavior of private agents. Expectations are formed rationally, which in this context of certainty amounts to perfect foresight. Thus, anticipated and realized values of the variables can only differ at the time of unexpected shocks or due to the arrival of new information about the future paths of exogenous variables.

Behavioral rules combine explicitly two benchmark specifications: the neoclassical case of unconstrained, intertemporally-optimizing firms and consumers, along with labor market clearing, and the Keynesian case of liquidity-constrained firms and households, along with wage inflexibility[3]. Following the standard theory of investment under convex adjustment costs (Lucas, 1967, Treadway, 1969), unconstrained firms maximize their market value and link their investment decisions to Tobin's q (Tobin, 1969), i.e., the present value of the additional profits associated with the marginal unit of capital relative to its installation cost (Hayashi, 1982). Unconstrained consumers gear consumption to their permanent income, as derived from intertemporal utility maximization along Ramsey-type behavior (Ramsey, 1928). In contrast, constrained firms (consumers) gear their investment (consumption) expenditure to their current profits (disposable income).

Technology and preferences are kept as simple as possible -- mostly by assuming unit elasticities of substitution. Two-stage budgeting in consumption and investment allows separation between the determination of expenditure and its allocation to domestic and foreign goods (thus avoiding the use of ad-hoc import functions). Harrod-neutral technical progress ensures the existence of steady-state growth, at a level given by the sum of the rates of technical progress and population growth.

The model's detailed structure is introduced next, starting with sector flow budget constraints and market equilibrium conditions. Behavioral equations for firms, consumers, the public sector, and the external sector follow. Variable notation and definitions are summarized in table 1; all prices are defined relative to the price of the domestic good or to the foreign price level. All stock and flow variables other than prices and interest rates are scaled to the labor force in efficiency units.[4] The model is written in continuous time. Dots over variables denote instantaneous time derivatives.

2.1 Budget Constraints

There are three basic agents in the model: the consolidated public sector, the domestic private sector, and the external sector. The first lumps the non-financial and financial (central bank) public sector together, the second aggregates private firms and consumers, and the third adds foreign investors, creditors, and trade partners. While some further disaggregation between firms and consumers is implicit below, we do not need it at this stage.

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[3] Money demand, exports, and wage setting are the only behavioral equations in the model not derived from first principles.

[4] Labor force in efficiency units is equal to the actual labor force augmented by Harrod-neutral technical progress (see table 1).

TABLE 1: NOTATION AND DEFINITION OF VARIABLES

1. Labor and Employment

L	Absolute employment
$LF = LF_0 \exp(pg\ t)$	Absolute labor force
LF_0	Base-period absolute labor force
$N = L \exp(tg\ t)$	Absolute employment in efficiency units
$NF = LF \exp(tg\ t) = LF_0 \exp(g\ t)$	Absolute labor force in efficiency units
pg	Population growth rate
tg	Harrod-neutral technical progress rate
$g = pg + tg$	Growth rate of absolute labor force in efficiency units
t	Time index
$l = L/LF = N/NF$	Employment (relative to labor force)
ld	Labor demand (relative to labor force)

2. General Notation

All stock and flow variables other than interest rates are defined in real terms and in efficiency labor force units. Current-price domestic (external) income and transfer flows and prices are deflated by the price of the domestic good (external price deflator). All stock and flow variables other than prices and interest rates are defined in terms of units of effective labor force. Domestic (external) relative prices are measured in real domestic (external) currency units. A dot over a variable denotes its time derivative.

3. Income, Transfer and Capital Flows

Domestic:

d	Dividends paid
op	Operational profits
td	Taxes
yd	Private disposable income
prem	Profit remittances abroad

External:

ftrg	Foreign transfers to the public sector
ftrp	Foreign transfers to the private sector
yf	Foreign income
dfi	Direct foreign investment

4. Stocks

Domestic:

a	Non-human wealth of the private sector
bg	Domestic debt of the public sector
fe	Stock of domestic equity (shares in domestic firms) held by foreigners
hb	Domestic base money
hu	Human wealth of the private sector
k	Physical capital
pvig	Present value of government investment subsidy
pvihb	Present value of cost of holding money

External:

fbg	Foreign assets held by the public sector
fbp	Foreign assets held by the private sector

TABLE 1 (Cont.)

5. Goods Flows

y	Gross output of final goods
cp	Private aggregate consumption
cmp	Private imported goods consumption
cnp	Private national-goods consumption
cng	Public national-goods consumption
inv	Gross domestic investment
in	Private national-goods investment
im	Private imported-goods investment
ig	Public investment subsidy
iac	Investment adjustment costs
x	Exports
mr	Intermediate imports

6. Various Rates

Domestic (External) Rates:

i (if)	Nominal interest rate on public debt (foreign assets/liabilities)
r (rf)	Real interest rate on public debt (foreign assets/liabilities)
i-r (if-rf)	Anticipated domestic (External) inflation rate
nmg	Rate of growth of the nominal money stock

7. Goods Prices

Domestic (all relative to the price of the domestic final good):

pc	Private aggregate consumption deflator
pi	Aggregate investment deflator

External (all relative to the price of the foreign final good):

pcmp	Private imported-goods consumption deflator
pim	Imported-goods investment deflator
pmr	Intermediate imports deflator
px	Deflator of export-competing goods

8. Other Prices

Domestic Prices:

q	Real equity price (Tobin's Q) in units of domestic output
v	Real wage per effective labor unit
W	Nominal wage per labor unit
PC	Nominal private consumption deflator

Real Exchange Rate:

$e = (E P^*)/P$	Real exchange rate
E	Nominal exchange rate
P	Nominal price of the domestic good
P^*	Nominal external deflator (foreign price level)

Walras' law makes one of the three sectoral budget constraints, when combined with goods and assets markets clearing, redundant. Hence we present the three budget constraints below only for expositional convenience. They are written equating above-the-line current account surpluses with below-the-line increases in net real asset holdings per effective labor force unit. Therefore above-the-line interest flows are adjusted for the changes in real asset holdings per effective labor unit due to growth in effective labor (g) and inflation.

Public expenditure includes public consumption, which is assumed to fall entirely on domestic goods, an investment subsidy paid to domestic firms[5], and interest paid on the outstanding stock of domestic public debt. Revenues include direct taxes, interest on net foreign assets of the public sector, and the inflation tax. The resulting adjusted operational surplus of the consolidated public sector finances acquisition of foreign assets and retirement of base money and domestic debt:

$$\text{(1)}\qquad \begin{aligned}&[td + e\ ftrg - cng - pi\ ig] - (r-g)\,bg + (g+\dot{P}/P)hb \\ &+ e(rf - g)\,fbg = e\,\dot{fbg} - \dot{bg} - \dot{hb}\end{aligned}$$

The external sector budget constraint -- the balance of payments identity -- reflects trade in goods and non-factor services, unrequited transfer payments to both the public and private sectors, loans from both domestic sectors, and foreign investment flows toward the private sector as well as profit remittances from the latter. Therefore, the external adjusted current account surplus and its financing, for convenience written in constant-price foreign currency units, is the following:

$$\text{(2)}\qquad \begin{aligned}&\left[\frac{x}{e} - pcmp\ cmp - pim\ im - pmr\ mr + ftrg + ftrp\right] \\ &+ (rf-g)\,[fbp + fbg] - \frac{prem}{e} = (\dot{fbp} + \dot{fbg}) - dfi\end{aligned}$$

The private sector budget constraint reflects the assumption that private firms do all production and investment decisions, own the economy's entire capital stock, and benefit from a public investment subsidy. Firm ownership is split between domestic consumers and foreigners. The consolidated domestic private sector (firms and consumers) budget constraint is given by:

$$\text{(3)}\qquad \begin{aligned}&[y - pi\ inv - pi\ iac - e\ pmr\ mr + e\ ftrp - td + pi\ ig - pc\ cp] \\ &- (g+\dot{P}/P)\,hb + (r-g)bg - prr\ fe + (rf-g)\ e\ fbp \\ &= \dot{hb} + \dot{bg} - e\ dfi + e\ \dot{fbp}\end{aligned}$$

[5] Public sector ownership of the capital stock could be mimicked by introducing a tax on profits proportional to the cumulative volume of public investment. For simplicity, we do not pursue this option here. Also, we are implicitly assuming that public investment is a perfect substitute for private investment.

2.2 Market Equilibrium Conditions

Equilibrium conditions are specified for goods, asset, and labor markets. Continuous market clearing at equilibrium prices and asset returns characterizes goods and asset markets, while sluggish wage adjustment is observed, under the general case, in the labor market.

Goods Markets

The single good produced domestically can be used for consumption and investment at home, or sold abroad (thus there is no distinction between production for domestic and export markets). It is an imperfect substitute for the foreign final good. However, the economy is small in its import markets. Equilibrium in the market for domestic goods can be expressed:[6]

$$\text{(4)} \qquad y = cnp + cng + in + pi\ iac + x$$

Under continuous market clearing, this is an implicit equation for the real exchange rate.

Asset Markets

Asset market equilibrium conditions are specified for base money, domestic bonds, and equity claims on the fixed capital stock. They reflect three features: perfect capital mobility, external interest rate determination in international markets (the small country assumption for financial markets), and absence of uncertainty (no risk premia). Imperfect substitutability between base money and other assets is reflected by a conventional transactions-based demand for base money. In turn, domestic and foreign bonds, as well as equity, are assumed perfect substitutes; hence their anticipated rates of return must be equalized at each point in time.

Base money market equilibrium assumes a conventional Cagan-type money demand (Cagan, 1956):[7]

$$\text{(5)} \qquad hb = \phi_1\, y^{\phi_2} \exp(\phi_3 i)$$

where $\phi_1, \phi_2 \geq 0, \phi_3 \leq 0$.

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[6] Notice that gross output y differs from conventional national-accounts value added or GDP for two reasons: y is defined as gross of the value of intermediate imports (e pmr mr) and gross of the value of investment adjustment costs (pi iac).

[7] Money demand could be explicitly derived from first principles by bringing money into the utility function (Sidrausky, 1967) or the production function (Fischer, 1974), or by imposing a cash-in-advance transactions technology (Clower, 1967). Easterly, Mauro and Schmidt-Hebbel (1992) present a generalized cash-in-advance transactions technology (with iso-elastic substitution of money and bonds) giving rise to a variable elasticity of money demand with respect to inflation, generalizing the iso-elastic Cagan form. Since each of these options has well-known drawbacks, however, and also to facilitate comparability with other (simpler) applied macroeconomic models, we choose the standard formulation in equation (5).

Arbitrage between domestic and foreign bonds leads to the uncovered interest parity condition:

(6) $$r = rf + \frac{\dot{e}}{e}$$

Similarly, arbitrage between equity and domestic public bonds is reflected by the following market equilibrium condition for equity prices (Tobin's q):

(7) $$\dot{q} = r\,q - \frac{d}{k}$$

Finally, the nominal interest rate is defined by the standard Fisher equation:

(8) $$i = r + \dot{P}/P$$

Labor Market

In the general case, wage rigidity (nominal and/or real) prevents the labor market from clearing instantaneously. We follow the conventional assumption that employment is determined by labor demand:

(9) $$l = ld$$

The labor market follows a wage-setting rule, which states that nominal wages are indexed to current and lagged consumer price inflation (with weights Θ and $1\text{-}\Theta$, respectively) and also respond to current labor market conditions (with an elasticity ω with regard to employment). Anticipating the simulations, the nominal wage equation is written in discrete-time form:

$$W = \exp(tg)\, l^{\omega} \left(\frac{PC}{PC_{-1}}\right)^{\theta} \left(\frac{PC_{-1}}{PC_{-2}}\right)^{1-\theta} W_{-1}$$

where $\omega \geq 0$, $0 \leq \Theta \leq 1$.

Using the relation between the nominal wage and the real (product) wage per effective labor unit:

$$\frac{W}{P} = \exp(tg\,t)\ v$$

we obtain, after some manipulations, the following real wage equation:

(10) $$v = 1^{\omega}\left(\frac{pc}{pc_{-1}}\right)^{\theta}\left(\frac{pc_{-1}}{pc_{-2}}\right)^{1-\theta}\left[\frac{P_{-1}/P_{-2}}{P/P_{-1}}\right]^{1-\theta} v_{-1}$$

This wage rule encompasses several interesting cases. First, when ω tends to infinity, it collapses into the neoclassical full employment condition. Second, for finite ω and $\theta = 1$, it represents the case of real wage resistance. In turn, with finite ω and $\theta < 1$, wages display nominal inertia. Finally, ex-post inflation can be defined from the relation between real and nominal balances per effective labor unit:[8]

$$\frac{P}{P_{-1}} = \frac{hb_{-1}}{hb}\,\frac{(1+nmg_{-1})}{(1+g)}$$

2.3 Firms

Technology is summarized by a Cobb-Douglas production function for gross output with Harrod-neutral technical progress, and quadratic adjustment costs for investment. The investment technology combines domestic and imported final goods according to a Cobb-Douglas specification, which allows for two-stage budgeting.[9]

There are two groups of firms. The first group is not subject to liquidity constraints and determines its investment according to the maximization of market value -- i.e., the present value of future dividends -- subject to convex adjustment costs. Investment is financed by equity sold to domestic and foreign agents and through the public investment subsidy. However, because the latter is distributed to firms in lump-sum fashion, it has no effect whatsoever on investment levels by of unconstrained firms; for them, the subsidy is simply a source of increased dividends.

The second group of firms is restricted in its access to financial markets and gears its current investment to current profits inclusive of the public investment subsidy. Thus, for these constrained firms changes in the subsidy will affect fixed investment levels.

The production technology for gross output is described by a Cobb-Douglas production function, which allows for substitution between value added (capital and labor) and intermediate imports:

(11) $$y = \alpha_0\, ld^{\alpha_1}\, k^{\alpha_2}\, mr^{(1-\alpha_1-\alpha_2)}$$

where $\alpha_0 \geq 0,\ 0 \leq \alpha_1, \alpha_2 \leq 1.$

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[8] Notice that, from (8), i-r is a measure of anticipated one-period ahead inflation. Because of the rational expectations assumption, it will equal actual (one-period ahead) inflation except at times of 'news' about the current and/or future paths of the exogenous variables.

[9] Wildasin (1984) provides exact conditions under which the investment technology gives rise to a two-stage investment decision. See also Hayashi and Inoue (1991) for a recent generalization with empirical applications.

Investment adjustment costs are defined by:

$$(12) \qquad iac = \mu\left[\frac{(inv - (g+\delta)k)^2}{k}\right]$$

where $\mu > 0$. This specification has the useful property that adjustment costs vanish in steady-state equilibrium -- i.e., when gross investment per unit of effective labor is just sufficient to maintain the capital/effective labor ratio. The evolution of the latter is described by:

$$(13) \qquad \dot{k} = inv - (g+\delta)k$$

Market value maximization for unconstrained firms, as well as current profit maximization for constrained firms, yields the standard marginal productivity conditions for variable inputs (labor and imported materials):[10]

$$(14) \qquad ld = \alpha_1 \, v^{-1} \, y$$

$$(15) \qquad mr = (1 - \alpha_1 - \alpha_2)\,(e\ pmr)^{-1}\, y$$

Investment demand is, as described above, a combination of the market-value maximizing investment rule of unconstrained firms and the profit-constrained investment of restricted firms:

$$(16) \qquad inv = \beta_1 \left[\frac{k}{2\mu}\left[\frac{q}{pi} - \frac{pvig}{pi\,k} - 1\right] + (g+\delta)\,k\right] + (1-\beta_1)\left[\beta_2\,\frac{op}{pi} + ig\right]$$

where β_1 is the share of non-constrained firms and β_2 is the marginal propensity of liquidity-constrained firms to invest out of operational profits; $0 \leq \beta_1, \beta_2 \leq 1$.

Unconstrained investment (the content of the first large right-hand side parenthesis) is derived from maximization of the value of the firm. This component of aggregate investment demand is geared to Tobin's <u>marginal</u> q -- i.e., average q minus the present value of the public investment subsidy per unit of capital[11]. This reflects the fact that optimal investment is determined by the addition to future dividends of the marginal unit of capital, which excludes the subsidy due to its lump-sum nature; by contrast, the average value of existing capital (i.e., the present value of the dividends associated with an

[10] The derivation of these conditions, as well as of the unconstrained component of investment in equation (16) below, follows the standard maximization of the value of the firm, subject to equations (11) - (13), not presented here for brevity.

[11] The general reasons that cause marginal and average q to diverge are spelled out in Hayashi (1982).

installed unit of capital) must include the subsidy. In turn, investment by constrained firms (the last term in the night-hand of (16)) rises one-for-one with the investment subsidy.

The present value of the public investment subsidy is implicitly defined by the dynamic equation:

$$(17) \qquad \dot{pvig} = (r-g)\ pvig - pi\ ig$$

Aggregate operational profits -- which determine capital formation by liquidity-constrained firms -- are defined as:

$$(18) \qquad op = y - v\ l - e\ pmr\ mr$$

and dividends are the sum of operational profits, net of investment expenditure, the investment subsidy and the proceeds of new issues of equity:

$$(19) \qquad d = op - pi\ inv - pi\ iac + pi\ ig + q(\dot{k} + gk)$$

After determining aggregate investment according to equation (16), the second-stage investment decision involves allocating investment expenditure between domestic goods and imports, according to a Cobb-Douglas aggregation which renders constant expenditure shares:

$$(20) \qquad in = \gamma\ pi\ inv$$

$$(21) \qquad im = (1-\gamma) \left[\frac{pi}{e\ pim}\right] inv$$

where γ is the share of national-goods investment in aggregate investment expenditure, satisfying

$0 \leq \gamma \leq 1.$

Therefore the aggregate investment deflator is a Cobb-Douglas average of national-goods investment prices and imported investment-goods prices:

$$(22) \qquad pi = (e\ pim)^{(1-\gamma)}$$

2.4 Consumers

Consumer preferences also allow two-stage budgeting, distinguishing between intertemporal aggregate consumption decisions and intratemporal consumption composition choices. Intertemporal preferences reflect unit intertemporal elasticity of substitution (i.e., logarithmic intertemporal utility);

intra-temporal preferences also display unit elasticity of substitution between domestic and imported goods.

Private sector non-human wealth includes four assets: base money, domestic public bonds, foreign assets, and equity claims on the domestic capital stock.

(23) $$a = hb + bg + e\ fbp + q(k-fe) - pvihb$$

where the present value of money holding costs pvihb has to be subtracted from financial wealth; it is implicitly defined by the dynamic equation:

(24) $$\dot{pvihb} = (r-g)\ pvihb - i\ hb$$

Human wealth is the present value of future labor income, net of taxes, and inclusive of current external transfers[12]. Under the assumption that individuals can freely borrow against their future labor income at the going real interest rate, the path of human wealth is characterized by:

(25) $$\dot{hu} = (r-g)\,hu + [td - vl - e\ ftrp]$$

Consumption of non-liquidity constrained consumers is derived from standard maximization of intertemporal utility over an infinite horizon, subject to the intertemporal budget constraint equivalent of the private sector flow constraint in equation (3) -- which is exactly consistent with wealth definitions in equations (23) - (25). Solving the maximization problem yields the standard result that private consumption of unconstrained households is equal to the subjective discount rate (net of effective labor growth) times total (human and non-human) wealth.[13]

Unconstrained consumers are of course Ricardian, as they internalize the government's intertemporal budget constraint by anticipating the entire stream of current and future tax payments. Because liquidity-unconstrained consumers face the same discount rate as the government[14], they are indifferent between tax, debt, or money financing. Therefore government debt -- although included in equation (23) -- ultimately "is not wealth" (Barro, 1974).

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[12] For expositional convenience, all taxes and transfers have been lumped together in the human capital flow equation.

[13] As before, the analytical derivations are standard and can be omitted.

[14] The assumption of equal discount rates is crucial for Ricardian equivalence to hold. Higher private sector discount rates, whether due to finite lifetimes (reflected by a given probability of death, as in Blanchard, 1985) or to a risk premium on consumers' debt relative to the borrowing cost of the government (e.g., McKibbin and Sachs, 1989) would cause Ricardian equivalence to break down.

Total private consumption demand is an aggregate of consumption by unconstrained and constrained consumers, with the latter consuming their current net labor income:[15]

$$\text{(26)} \qquad cp = \left[(\lambda_2 - g)\,\frac{a + hu}{pc}\right] + (1 - \lambda_1)\left[\frac{yd}{pc} - (\lambda_2 - g)\,\frac{hu}{pc}\right]$$

where $0 \leq \lambda_1 \leq 1$ is the share of unconstrained consumers, and λ_2 is the subjective discount rate. Disposable income is defined by:

$$\text{(27)} \qquad yd = v\,l + e\,ftrp - td$$

After determining aggregate private consumption levels according to equation (25), the second-stage private consumption decision allocates it to domestic goods and imports, according to Cobb-Douglas intratemporal preferences:

$$\text{(28)} \qquad cnp = \eta\, pc\, cp$$

$$\text{(29)} \qquad cmp = (1 - \eta)\left[\frac{pc}{e\ pcmp}\right] cp$$

where $0 \leq \eta \leq 1$ is the share of national-goods in aggregate private consumption expenditure. Therefore the aggregate private consumption deflator is a Cobb-Douglas index of national-goods prices and imported consumption goods prices:

$$\text{(30)} \qquad pc = (e\,pcmp)^{(1-\eta)}$$

2.5 Government

The public sector could either determine policy exogenously or derive it from optimization of some objective function; for realism and simplicity, we choose the first option. Thus public consumption and investment expenditures are exogenously given. To finance its activity, the public sector can choose between taxes, money, domestic debt or external borrowing (or any combination of them).

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[15] Unconstrained consumption is derived from the standard intertemporal utility maximization, subject to the preference structure mentioned above and an intertemporal budget constraint which combines equations (23) - (25). The derivation is not presented here for brevity. For discussion and empirical analyses of the implications of liquidity constraints for consumer behavior -- as well as for Ricardian equivalence -- see Hayashi (1985), Hubbard and Judd (1986), Bernheim (1987) and Leiderman and Blejer (1989).

The accumulation of per capita real balances can be characterized as:

$$\text{(31)} \qquad \dot{hb} = \left[nmg - (\dot{P}/P) - g\right] hb$$

where it is worth noting that the rate of money growth will be endogenous under money finance of the deficit and exogenous otherwise.

2.6 Foreigners

The demand by foreigners for the domestically produced good is given by a conventional export function, which embodies imperfect substitution between the national good and the foreign final good and a normal relation to foreign income:

$$\text{(32)} \qquad x = \rho_1 (e\ px)^{\rho_2}\ yf^{\rho_3}$$

where $\rho_1, \rho_2, \rho_3 \geq 0$.

Finally, the path of foreigners' equity holdings remains to be described. At every instant, foreign investors use dfi units of foreign currency (in real per capita terms) to purchase domestic shares, whose price in terms of domestic output is q. Hence their per-capita holdings of equity evolve according to the equation:

$$\text{(33)} \qquad \dot{fe} = \frac{e\ dfi}{q} - g\ fe$$

In turn, profit repatriation equals the total volume of dividends earned by foreign investors, which is given by the product of the share of foreign-held equity and total dividends:

$$\text{(34)} \qquad prem = \frac{fe}{k}\ d$$

3. STEADY STATE AND STABILITY

3.1 The Steady State

The long run equilibrium of the model is characterized by constant asset stocks in real per capita terms, constant asset prices (i.e., Tobin's q and the real exchange rate) and constant real wages with full employment. Thus, the government's budget must be balanced, and the current account deficit must equal the exogenously given flow of foreign investment.

Since the per capita real money stock is constant, long run inflation equals the rate of expansion of per capita nominal balances nmg-g. In turn, with a constant real exchange rate, domestic and foreign real interest rates are equalized, and nominal exchange depreciation is determined by the difference between domestic and (exogenously given) foreign inflation. Hence, across steady states changes in the rate of money growth are fully reflected in the inflation rate (and thus in the nominal interest rate) and in the rate of nominal depreciation.

By combining the model's equations, the steady-state equilibrium can be reduced to two independent equations in the real exchange rate, real wealth, and the real interest rate: a goods market equilibrium condition, and a zero private wealth accumulation condition (in real per capita terms). Together they imply a constant stock of per capita net foreign assets. Real wealth accumulation can only cease when per capita consumption equals the per capita return on wealth. But the latter is just (r-g) times the wealth stock (because of the assumption of perfect asset substitutability), while in the steady-state the former equals (λ_2-g) times the wealth stock (from (25)-(27)). Hence, this implies the well-known result that the rate of time preference λ_2 must equal the domestic and foreign real interest rates:

(35) $$\lambda_2 = r = rf$$

Thus we would be left only with the goods market equilibrium condition to determine both wealth and the real exchange rate. This means that their steady-state values (and hence also those of all variables that depend on them) depend not only on the long-run values of the exogenous variables, but also on the initial conditions and on the particular adjustment path followed by the economy -- and therefore on parameters governing the speed of adjustment such as the degree of real wage rigidity or the magnitude of adjustment costs associated with investment. In other words, the model exhibits hysteresis. As noted by Giavazzi and Wyplosz (1984), this follows from the assumption of forward-looking consumption behavior derived from intertemporal optimization by infinitely-lived households with a constant rate of time preference and facing perfect capital markets.

Nevertheless, certain important features of the steady state can easily be determined[16]. On the production and investment side, long run equilibrium is characterized by full employment and a constant capital stock in per capita terms. From (13), gross investment is just inv = $(g+\delta)k$, and adjustment costs are identically zero (from (12)). In turn, from (7), (17), (18) and (19), Tobin's q in steady state is given by:

(36) $$q = \frac{F_k - pi\ (g+\delta)}{(rf-g)} + pvig/k$$

where F_k is the marginal productivity of capital. If no firms are liquidity constrained (that is, $\beta_1=1$ in (16)), then (16) further guarantees that marginal q equals the price of capital goods or, equivalently, that average q equals the price of capital plus the unit investment subsidy (i.e. q = pi + pvig/k). Thus, from the above equa'on the marginal product of capital equals its user cost:

[16] Giavazzi and Wyplosz (1985) provide a method to solve analytically certain linear models with hysteresis. They show that the long-run equilibrium depends on initial conditions and on the speed of adjustment of the system. Since our model is nonlinear, however, a comparable solution technique is not available.

(37) $$F_k = pi\ (rf+\delta)$$

Notice, however, that pi is an increasing function of the real exchange rate because of the import content of capital goods. In turn, for a given capital stock F_k is a decreasing function of the real exchange rate, due to the use of imported materials in production. Hence, (37) defines an inverse relationship between the steady-state capital stock and the real exchange rate: a real depreciation must reduce the long-run capital stock, and (from (11) and (14)) also output and the real wage. It also follows that the long-run values of these variables depend, like the real exchange rate, on initial conditions and on the adjustment path of the economy[17].

What if some firms are liquidity constrained (i.e., $\beta_1 < 1$) ? The negative long-run relationship between the capital stock and the real exchange rate is unaltered; however, in the steady state q does not equal the subsidy-inclusive price of capital goods, nor does F_k equal the user cost of capital. Provided the marginal propensity to invest of constrained firms (β_2 in (16)) is not too large[18], the marginal product of capital must exceed the user cost, and Tobin's q must exceed the price of capital goods plus the investment subsidy. Formally:

(38) $$F_k = pi\ [(rf+\delta) + f]$$

where $f > 0$ is a term that depends positively on the adjustment cost coefficient μ and the rate of depreciation of capital, and negatively on β_1, β_2 and the investment subsidy.[19] Tobin's q under liquidity constraints becomes:

(39) $$q = \frac{pi\ [(rf+\delta) + f]}{(rf+\delta)} + pvig/k$$

The intuition behind these results is simple: with binding liquidity constraints, firms cannot invest as much as they would want and therefore cannot close the gap between the shadow value of one additional unit of capital and its cost. This implies that, for a given long-run real exchange rate, liquidity

[17] This is in contrast to similar dynamic models (e.g., Sachs (1983), Giavazzi et al. (1982)), where capital goods have no import content and thus the steady-state marginal product of capital (as well as the capital stock and real output) depends only on the relative price of materials in terms of domestic goods (e pmr in our notation). Here the import content of capital goods creates a negative relationship between the real exchange rate and F_k, even for a given real cost of imported inputs. Gavin (1991) and Serven (1991) have shown that this has important consequences for the effects of macroeconomic policies on investment.

[18] The exact condition is $\beta_2 < (g+\delta)/(rf+\delta)$.

[19] The exact expression for f is $f = \dfrac{\beta_1(rf+\delta) + (1-\beta_1)\ 2\mu\ (rf-g)(g+\delta)}{\beta_1 + (1-\beta_1)\ 2\mu\ (rf-g)(\beta_2+\frac{z}{\alpha_2})} - (rf+\delta)$, where z is the public investment/gross output ratio.

constraints will cause the economy to achieve a lower capital stock and output, and a lower real wage as well, than in the fully unconstrained case.

Using (37) or (38), the steady-state goods market equilibrium condition (4) can be rewritten as:

$$(40) \qquad y(e,...) = \eta \ (rf-g)(a+hu) + cg + \gamma \ pi \ (g+\delta) \ k(e,...) + x(e,...)$$

which defines an inverse relationship between the long-run real exchange rate and real wealth: an increase in the real exchange rate (a real depreciation) generates excess demand for domestic goods and requires a fall in private wealth and consumption to restore market equilibrium.[20] As noted before, the particular levels of real wealth and the real exchange rate that will obtain in the long run depend on the initial conditions and on the dynamic path followed by the economy.

Aside from real wealth, the other key element in the determination of the long-run real exchange rate is the distribution of demand between the public and private sectors. Since public consumption is assumed to have no import content, an increase in cg creates excess demand for domestic goods and leads to a real appreciation. As argued before, this would cause the capital stock and output to rise as well.

An important implication of the model's hysteresis property is that transitory disturbances have long-run effects. For the case of fiscal policy, this has been recently highlighted by Turnovsky and Sen (1991) in a non-monetary model.[21] In our framework this also means that even transitory monetary disturbances can have permanent real effects: if some consumers are liquidity constrained (or myopic), a transitory increase in inflationary taxation matched by a reduction in direct taxes will raise disposable income and consumption, leading to reduced wealth accumulation and eventually causing a fall in long-run wealth and a permanent real depreciation[22].

3.2 Dynamics, Stability and Model Solution

The precise dynamics of the model depend on the way the public deficit is financed. Under tax or money finance, the model is driven by ten dynamic equations. Four of them describe the time paths of predetermined variables: the capital stock, private foreign assets, foreign holdings of equity, and the real wage. At each moment in time, these variables are given by current and past values of endogenous and exogenous variables. Further, the four predetermined variables have to satisfy well-defined initial

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[20] This is guaranteed by our assumption of constant expenditure shares of domestic goods and imports in private consumption and investment. With more general specifications allowing lower substitutability between domestic and foreign goods, a positive association between real wealth and the real exchange rate in steady state (i.e., a "contractionary devaluation" of the type analyzed by Krugman and Taylor (1978)) could not in principle be ruled out.

[21] Turnovsky and Sen (1991) use a model with intertemporally optimizing consumers to show that transitory fiscal disturbances have long-run effects. Their result depends critically on the endogeneity of labor supply in their framework, which makes long-run employment endogenous. In our case, the dependence of the long-run capital stock on the real exchange rate ensures that transitory fiscal shocks have permanent effects despite the constancy of full employment across steady states.

[22] Without liquidity constraints, a monetary acceleration (an increase in nmg) would just amount to a change in the composition of taxation between the inflation tax and (present or future) direct taxes, without any effect on wealth, consumption, or any other real variable.

conditions. Under debt (domestic or foreign) finance, a fifth dynamic equation describes the time path of the relevant debt stock.

The remaining six dynamic equations describe the time paths of 'jumping' variables: Tobin's q, the real exchange rate, real money balances, human wealth, the present value of the investment subsidy, and the present value of the cost of holding money. They are not predetermined by the past and can react freely to 'news' about the current and future values of the exogenous variables; their equilibrium values at any point in time depend on the entire future anticipated path of the forcing variables. For the complete dynamic system not to explode, these jumping variables have to satisfy certain terminal (transversality) conditions. Solving the model basically amounts to finding initial values for the non-predetermined variables such that, following a shock, the model will converge to a new stationary equilibrium.

The necessary and sufficient conditions for the existence and uniqueness of such initial values in linear models of this type have been investigated in the literature and will not be discussed here[23]. However, this is not the case for large nonlinear models such as this one[24]. While a formal proof of stability cannot be provided, numerically the model was always found to converge to the new long-run equilibrium under reasonable parameter values.

The requirement that the predetermined variables satisfy initial conditions, while the jumping variables must satisfy terminal conditions, poses a two-point boundary-value problem, for whose numerical solution several different techniques exist. One leading example is the "multiple shooting" method proposed by Lipton et al. (1982), which solves the model over a fixed time horizon starting from arbitrary guesses for the initial and future values of the jumping variables. The second is the "extended path" algorithm of Fair and Taylor (1983), which first solves the model also over a fixed time horizon, but starting from arbitrary guesses for the expected values of the jumpers, which are updated until they become sufficiently close to the actual values obtained from the model's equations, and then gradually extends the horizon until the solution path is unaffected by the addition of more time periods.

For the simulations below, we combine both techniques. First, we solve the model over a given time horizon using multiple shooting. Then we extend the horizon and recompute the solution path until the resulting changes in the solution trajectory of the endogenous variables fall below a certain tolerance[25], at which time the process stops. In practice, the length of the simulation horizon required for this procedure to converge is strongly affected by two parameters governing the speed of adjustment of the system: the elasticity of real wages to unemployment (i.e., the slope of the augmented Phillips curve), and the magnitude of adjustment costs associated with investment. Finally, the model is discretized for the numerical simulations, so for any variable x, $\dot{x} = x_{+1} - x$.

[23] See Blanchard and Kahn (1980) and Buiter (1982).

[24] In principle, we could linearize the system around a steady state to determine the conditions under which the transition matrix possesses the saddle-point property. But for a tenth-order system this would be an analytically intractable task.

[25] We used a very strict convergence criterion, requiring that the maximum relative change between solutions in any variable at any time period not exceed one-thousandth of one percent. This typically required a horizon between sixty and eighty periods for convergence.

4. SIMULATION RESULTS

This section discusses the dynamic response to external shocks, by presenting simulation results for the model introduced above. We simulate the dynamic adjustment to a favorable foreign transfer shock (an external grant) and a favorable terms-of-trade shock (a decline in the price of the intermediate import used in production, say oil). The first-round magnitude of both shocks is common, equivalent to a 4% gain of initial steady-state GDP. We start by introducing the values of model parameters and exogenous variables and presenting the values of the endogenous variables at the initial steady-state equilibrium. Then we discuss the simulation results.

4.1 Model Parameterization and Initial Steady-State Solution

According to the model structure spelled out above, three economies will be considered. (i) a neoclassical (NC) benchmark, (ii) an economy with liquidity constraints but with full-employment (LCFE), and (iii) a Keynesian benchmark combining liquidity constraints and unemployment (LCUN). Table 2 summarizes the common and distinct parameter values for these three economies. Under the neoclassical benchmark, liquidity constraints on consumption and investment are ruled out ($\beta_1 = \lambda_1 = 1.0$). For the LC cases, the latter coefficients are reduced to 0.5. For the full-employment cases, the elasticity of real wage changes with respect to current employment is set at a very high level ($\omega = 1{,}000$) and indexation to lagged consumer-price inflation is ruled out ($\Theta = 1.0$). By contrast, wage-setting behavior in the Keynesian benchmark gives rise to unemployment, as a result of a low employment elasticity ($\omega = 0.25$) and an important role of lagged inflation ($\Theta = 0.5$). The latter feature reflects nominal stickiness of wages.

Numerical values for other coefficients in the structural equations were borrowed from empirical estimates (Serven and Solimano, 1991, Elbadawi and Schmidt-Hebbel, 1991) and preceding simulation models (McKibbin and Sachs, 1989, Giavazzi and Wyplosz, 1984) for various countries, complemented by estimates deemed to be representative for open economies. Table 2 also reports these parameter values shared by the three economies. Base money demand exhibits a unitary income elasticity. The interest semi-elasticity is 0.5, implying a seignorage-maximizing inflation rate of 200%. The share of labor, capital and intermediate imports in production (gross of imported materials) is 0.6, 0.3, and 0.1, respectively. The quadratic adjustment coefficient of investment is 2.5 and the rate of capital depreciation is 0.04. The import component of aggregate investment is relatively large (0.4), exceeding that of private consumption (0.1). The rate of discount of consumers is set at 0.06, which, according to equation (35), is also equal to the foreign real interest rate. Export demand exhibits a unitary foreign-income elasticity. The price elasticity of the foreign demand for exports is 1.5.

Before discussing the values of exogenous variables, a remaining question on model closure has to be addressed: one residual endogenous variable for each of the two independent budget constraints remains to be chosen. For the simulations discussed below, the adjusting variable for the public sector is total taxes (td); for the private sector the residual budgetary variable is foreign asset holdings (fbp).[26]

The numerical values for exogenous variables are also based on both representative country magnitudes (as ratios to output) and previous models. Table 3 summarizes the exogenous variables for

[26] Actual model simulations assume that the private sector intratemporal budget constraint (equation (3)) is the redundant budget constraint, hence it is excluded from the set of model equations. (Obviously the intertemporal budget constraint is used in deriving optimal private consumption levels). Hence td and fbp are the endogenous variables associated to the public sector budget constraint (1) and the external sector budget constraint (2), respectively.

the initial steady state, common to the three economies. While the simulations show the response to a change in two exogenous variables (foreign transfers and price of intermediate imports), all other exogenous variables are maintained at the levels summarized in table 3. Because in the initial steady-state domestic output per efficiency labor force unit is 1.0, all exogenous variables can be interpreted as ratios to initial steady-state output. Both the public and private sector benefit from foreign transfers, at 0.015 each. Foreign income is normalized at 1.0. Foreign direct investment flows amount to 0.005. Public indebtedness in both foreign and domestic capital markets is 0.30 and 0.20, respectively. The sum of public consumption and investment is 0.19, with a relatively large share of consumption. All absolute foreign price indices are normalized at 1.0, with zero foreign inflation. The rate of growth of the labor force in efficiency units is equal to the sum of population growth (2%) and the rate of Harrod-neutral technical progress (1%). The foreign real (and nominal) interest rate is 6%. Finally, nominal base money grows at 5%.

The initial steady-state values of endogenous variables for the NC economy (and of most endogenous variables for the liquidity-constrained economies)[27] are reported in table 4. Initial (and final) steady-state output growth is determined by the rate of growth of the labor force in efficiency units (3%). Hence output per efficiency labor is constant; parameter values were chosen so that its numerical value is 1.0.

At the initial steady-state equilibrium, total private sector (or consumer) wealth is almost 20 times output, corresponding to the sum of non-human wealth (4.990) and human wealth (14.417). The four components of non-human wealth (other than the exogenous public debt) are domestic base money (0.15), the domestic-currency value of foreign assets (0.874), the net value of equity given by the product of q (0.6) and the difference between the total capital stock (3.0) and the equity owned by foreigners (0.115), and minus the present value of costs derived from holding base money (0.4).

Steady-state inflation at 2% is given by the difference between money growth and output growth. Seigniorage is defined as the product of base money holdings and its rate of growth. At initial and final steady-state equilibria, seigniorage is 0.75% of output -- the amount required to finance an operational public sector deficit of the same magnitude. Note that only at steady-state positions seigniorage is equal to the sum of the inflation tax (0.3% of output) and the growth effect on money demand (0.45% of output). At non-stationary equilibria, accumulation of money holdings drive a wedge between seigniorage and the latter sum.

Initial steady-state private consumption is 0.58, mostly comprised by national-goods consumer spending. Stationary gross domestic investment is 0.21, all of which goes to replace depreciated capital per efficiency labor force unit. 60% of investment falls on domestically-produced goods. Investment adjustment costs are zero at the steady state, because they are only incurred on net investment. Exports are 0.20, intermediate imports are 0.10, and total imports reach a level of 0.242. The corresponding trade deficit of 0.042 and profit remittances (0.10) are financed by foreign transfers (0.03), the net return (net of growth) on foreign-held assets, which yields 0.017, and direct foreign investment flows (0.005).

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[27] As discussed in section 3.1, Tobin's q is higher and investment is lower under binding liquidity constraints than in the neoclassical economy. In fact, initial steady-state values in the LC economies are 1.479 for q and 0.208 for gross domestic investment, which can be compared to the stationary values in the NC economy, reported in table 4. The stationary capital stock is slightly lower in the LC economies (2.973), but the total equity value (q times k) is larger. Higher equity more than offsets lower foreign assets held by the private sector (equal to 0.853 in the LC economies). Hence steady-state total consumer wealth and consumption are slightly larger in the LC economies. The stationary trade deficit is slightly lower in the LC economies, as the return on foreign asset holdings has slightly deteriorated due to the lower stock of private foreign asset holdings. All other variables remain unchanged in the LC economies as compared to the NC case.

The latter flow finances an initial current account deficit (net of accumulation of foreign assets to maintain constant asset/output ratios) of 0.005.

The steady-state nominal interest rate of 8% equals the sum of long-run domestic inflation and the real interest rate. At a real exchange rate of 1.0, all relative goods prices are also equal to 1.0. The price of equity in units of national goods (q) is 1.444. Having normalized employment at 1.0, and with a labor share in production of 0.6, the real product wage is also equal to 0.6.

TABLE 2: PARAMETER VALUES FOR SIMULATIONS

Base money demand	$\phi_1 = 0.16$, $\phi_2 = 1$, $\phi_3 = -0.5$
Wage-setting rule	$\omega = 1{,}000$ (Neoclassical and Liquidity Constraints) or 0.25 (Liquidity Constraints with Unemployment), $\Theta = 1.0$ (Neoclassical and Liquidity Constraints) or 0.5 (Liquidity Constraints with Unemployment)
Production function	$\alpha_0 = 0.91$, $\alpha_1 = 0.6$, $\alpha_2 = 0.3$
Investment adjustment costs	$\mu = 2.5$
Physical capital depreciation rate	$\delta = 0.04$
Private investment demand	$\beta_1 = 1.0$ (Neoclassical) or 0.5 (Liquidity Constraints), $\beta_2 = 0.5$
Domestic content of investment	$\gamma = 0.6$
Private consumption demand	$\lambda_1 = 1.0$ (Neoclassical) or 0.5 (Liquidity Constraints), $\lambda_2 = 0.06$
Domestic content of consumption	$\eta = 0.9$
Export demand	$\rho_1 = 0.2$, $\rho_2 = 1.5$, $\rho_3 = 1$

TABLE 3: VALUES OF EXOGENOUS VARIABLES

Income, Transfer and Capital Flows		All Foreign Price Levels	1.0
Foreign transfer to public sector (ftrg)	0.015	Rates	
Foreign transfer to private sector (ftrp)	0.015		
Foreign income (yf)	1.0	Population growth (pg)	0.02
Foreign direct investment (dfi)	0.005	Harrod-neutral technical progress (tg)	0.01
		Foreign real interest (rf)	0.06
Stocks		Nominal base money growth (nmg)	0.05
Domestic debt of public sector (bg)	0.2		
Foreign assets held by public sector (e fbg)	-0.3		
Goods Flows			
Public national-goods consumption (cnp)	0.15		
Public investment subsidy (ig)	0.04		

TABLE 4: INITIAL STEADY-STATE VALUES OF ENDOGENOUS VARIABLES

Income, Capital and Transfer Flows		**Employment** (l)	1.0
Operational profits (op)	0.300	**Output** (y)	1.0
Dividends paid (d)	0.260		
Taxes (td)	0.183	**Rates**	
Private disposable income (yd)	0.433		
Profit Remittances (prem)	0.01	Nominal interest rate on public debt (i)	0.08
		Real interest rate on public debt (r)	0.06
Stocks		Inflation rate	0.02
Total private sector wealth (a+hu)	19.407	**All Relative Goods Prices**	1.0
Non-human wealth of private sector (a)	4.990		
Stock of domestic equity held by foreigners (fe)	0.115	**Other Prices**	
Domestic base money (hb)	0.15		
Human wealth of private sector (hu)	14.417	Real equity price (Tobin's q)	1.444
Physical capital (k)	3.0	Real wage per effective labor unit	0.6
Present value of government investment subsidy (pvig)	1.333	Real exchange rate (e)	1.0
Present value of cost of holding money (pvihb)	0.40		
Foreign assets held by private sector (e fbp)	0.874		
Goods Flows			
Private aggregate consumption (cp)	0.582		
Private imported-goods consumption (cmp)	0.058		
Private national-goods consumption (cnp)	0.524		
Gross domestic investment (inv)	0.210		
Private national-goods investment (in)	0.126		
Private imported-goods investment (im)	0.084		
Investment adjustment costs (iac)	0		
Exports (x)	0.20		
Intermediate imports (mr)	0.10		
Total imports (mr)	0.242		
Trade balance	-0.042		
Current account balance	-0.005		

The simulations for the foreign-transfer shock below consider three types of shocks: permanent unanticipated (P) disturbances (hitting the economy from period 1 to terminal period T), transitory unanticipated (TU) shocks (hitting during periods 1-4), and transitory anticipated (TA) shocks (hitting during periods 2-5). In the case of the oil price windfall, only a permanent (P) shock will be considered.

The discussion of the simulation results below focuses on the deviations from an initial steady-state equilibrium (represented by period 0), distinguishing between the impact effects (in period 1) and the transition toward the new steady-state equilibrium (from period 2 to terminal period T). The discussion of the simulations will be based on the figures depicting the dynamic paths of the main endogenous variables. For the foreign-transfer simulations, each figure page is divided into an upper panel, which reports the dynamic trajectories under the three types of shocks (P, TU, and TA) for the NC case, and a lower panel which combines the three shock types with the two remaining model categories: LCFE and LCUN. For the oil price windfall simulations, each panel represents a different variable, depicting three dynamic trajectories to a permanent shock, one for each benchmark economy. The figures report trajectories of endogenous variables for periods 0 (the initial steady state), 1 to 11, and T-1 and T. The terminal period T varies between 70, 80, and 90 periods.

4.2 A Foreign Transfer Shock

The dynamic trajectories of the main endogenous variables in response to a 4%-of-output transfer from the rest of the world to the public sector (ftrg rises from 0.15 to .055) are shown in Figures 1-10, for different model categories and types of shocks.

Taxes are the adjusting variable for the public sector budget. Therefore the foreign transfer to the public sector is completely passed on to the private sector by a tax reduction. Private sector disposable income and wealth rise accordingly, leading to increased consumption. Higher private consumption leads to both a real exchange rate appreciation and higher output during period 1 when the shock materializes (under P or TU shock types) or is first known to materialize in subsequent period 2 (under a TA shock type). Additional output increases in the following periods are a result of capital accumulation (which responds only gradually to higher investment profitability), and cause a depreciation of the real exchange rate.

First consider the neoclassical economy (NC), positively affected by a permanent shock. Ricardian consumers internalize the government's intertemporal budget constraint, anticipating current and future foreign transfers and corresponding tax cuts. Consumer wealth rises in period 1 (Fig. 1, upper panel) and continues to rise thereafter (due to the ongoing capital and output rise), approaching asymptotically its new long-run level. Private consumption increases accordingly, exhibiting an impact effect of plus 4 percentage points (pp.) of output (Fig. 2). In the long run, consumption increases by 9.7%, slightly exceeding the 8.9% rise in stationary consumer wealth.[28]

The consumption-based increase in aggregate demand causes a contemporaneous real appreciation (Fig. 4)[29] and an output expansion (Fig. 3). Higher production in period 1 is made possible by

[28] The 0.8% difference is due to the decline by this magnitude of the private consumption deflator, prompted by the real exchange rate appreciation.

[29] In figure 4, an appreciation is represented by a decline in the value of e, which accords to the model's definition of the real exchange rate.

importing more intermediate goods in response to the appreciated real exchange rate, and hence by shifting the input mix away from value added. In subsequent periods the real exchange rate depreciates as a result of aggregate supply shifts due to a higher capital stock. Therefore the real exchange rate initially overshoots its new long-run level -- a result of the gradual supply response that partly offsets the initial appreciation. In the new steady-state, the real exchange rate exhibits a 7.4% appreciation as relative to the initial long-run equilibrium, while output has risen by 2.8%.

With the transition path characterized by a gradual real exchange rate depreciation, the domestic real interest rate slightly exceeds its foreign counterpart throughout the transition (Fig. 5). Aggregate private investment is determined by the ratio of Tobin's q (in units of output) to the aggregate investment price deflator. The decline in the latter -- due to cheaper capital goods imports -- dominates the reduction in Tobin's q, and hence the impact effect is an increase in aggregate investment by some 1.5 pp. of output (Fig. 6). Subsequent additions to the capital stock drive down the profitability of new projects and hence investment levels off toward its new long-run value. The latter exceeds the initial value due to the higher capital stock (per unit of output), which requires higher replacement investment.

The impact effect on inflation (defined in Fig. 7 as the backward-looking price change between periods t-1 and t) is a reduction by 1.1 pp. from the initial (and final) steady-state value of 2%. The reason for lower short-run inflation is the need to accommodate a higher money demand (which expands with higher real income) under a fixed monetary growth rule. Subsequently inflation converges monotonically -- from below due to transitorily high income growth -- toward its unchanged long-run equilibrium level.

An interesting result refers to the current account adjustment between the initial and (unchanged) final long-run equilibrium deficits of 0.5% of output. Since Ricardian consumers raise consumption in anticipation of future output gains, the current account deficit <u>increases</u> by 0.5 pp. of output in period 1 (Fig. 8). The initial higher deficit is gradually reversed in subsequent periods as the anticipated output gains materialize.

Finally, the initial increase in aggregate demand and subsequent rise in the capital stock stimulate labor demand. Since labor is fully employed, higher labor demand raises the real wage (Figs. 9 and 10). The new long-run real wage exceeds the initial level by 2.8%.

It is worth to underscore that all these dynamic effects arise because of the import content of productive inputs. If capital goods had no import content, and if no imported materials were required for production, adjustment to the transfer shock would simply entail an instantaneous rise in private wealth and consumption, along with a real appreciation, without any change in real output, the capital stock, or the current account.

Next consider the case of a temporary unanticipated (TU) foreign transfer in this neoclassical economy, lasting from periods 1 to 4. The qualitative effects on most variables are very similar to the case of a permanent shock. However, a temporary decrease in taxes raises permanent income by a small amount, hence consumption increases only by little. Consequently, all the effects described above occur with diminished force. The only qualitative difference is that now the current account shows a significant surplus while the shock lasts -- a surplus of approximately 4% of output as compared to the permanent shock -- as consumers accumulate wealth to smooth out their consumption over the entire future horizon (see the dashed line in the top panel of Fig. 8).

Consider now the case of a temporary anticipated (TA) shock, which takes place during periods 2 to 5. The effects are nearly identical to the unanticipated temporary shock. Consumption rises already in period 1 in anticipation of future lower taxes.[30] The current account goes initially into deficit, followed by four periods of surplus while the transfer lasts.

Next we focus on a full-employment economy with liquidity-constrained consumers and firms (LCFE). Aggregate investment and consumption respond only in part to forward-looking variables (wealth and Tobin's q), while now they are also sensitive to contemporaneous flow variables (consumer disposable income and operational profits). For the P shock the dynamic paths of the endogenous variables are similar to the neoclassical case.

Richer dynamics are observed under temporary shocks in the LCFE economy. Because temporary tax cuts relax liquidity constraints of some consumers, aggregate consumption is boosted far beyond the smooth consumption levels of the NC economy during the 4 periods of shocks (cf. upper and bottom panels, Fig. 2). While consumer wealth declines during the 4 periods of shocks (Fig. 1, bottom panel), private consumption levels increase during the periods of tax cuts (Fig. 2, bottom panel). Thus the LCFE economy exhibits a more pronounced cycle. Output expansion and real exchange rate appreciation are stronger than under the comparable temporary shocks in the NC economy, following U or inverted-U patterns during the 4 periods (bottom panels, Figs. 3 and 4).

The dynamics of the real interest rate, determined by the real exchange rate fluctuations, merit a closer look. Under a TU shock, the real exchange rate depreciates at a low rate during the next 3 periods (2 to 4), then depreciates strongly in period 5 (due to the decline of consumption by liquidity-constrained agents), and subsequently depreciates again at a low rate until converging to the new long-run value. This implies that the real interest rate exhibits a one-period spike in period 4 (reaching 8%), in anticipation of the strong real exchange rate depreciation. Compare this result to what happens under a TA shock which starts in period 2. Then the initial real exchange rate appreciation continues through period 2, only to be reverted in period 3 and thereafter, with a strong depreciation occurring in period 6. Hence the real interest rate exhibits a trough in period 1 and a spike in period 5, before slowly converging to the (unchanged) long-run value of 6%.

Aggregate investment reflects now the influence of both the shadow price of capital and operational profit flows. As Tobin's q declines more than operational profits increase, aggregate investment falls during the four periods of shocks.

Inflation falls in the first period, as in all previous cases, due to the adjustment of real balances to higher money demand. However, in the TU and TA cases inflation exhibits a cycle that mimics the developments in goods markets.

Finally, note that the transitory current account surplus is lower than in the NC economy since consumption is higher due to the 4-period relaxation of liquidity constraints.

The third and last economy to consider is the Keynesian benchmark, which combines liquidity constraints with wage rigidity and unemployment (LCUN). The new long-run values of all endogenous variables are similar to those attained in the previous full-employment economy (LCFE). The difference lies in the adjustment path: now real wages do not rise as much in response to higher labor demand, and

[30] The rise is slightly smaller than under TU because the temporary tax reduction must be discounted one additional period.

hence employment initially rises above the full-employment level. Lagged wage indexation introduces a strongly cyclical pattern of real wages and employment, which is absent in the full-employment economies.

In the case of a P shock, total wealth exceeds that of the LCFE case, a result of higher employment and production during the adjustment period. Consumption rises accordingly, although as a ratio to (higher) output it remains unaltered from the previous economy. Output follows an oscillatory path, first rising to a temporary peak in period 3, then declining to reach a trough in period 8, and finally converging toward its long-run value (which exceeds the levels achieved by the full-employment economies). The output dynamics are a result of slowly increasing capital and the cyclical pattern of employment. The latter exhibits a peak of 2.3% over-employment in period 2 (as real wages decline in that period due to lagged indexation), after which it starts an asymptotic convergence back to full employment. The real exchange rate mimics the dynamics of output after period 1; the real interest rate evolves accordingly. Positive output growth reduces inflation below its 2% long-run value during the first three periods.

Tobin's q, as opposed to all preceding runs, increases through period 2, when it reaches its peak. This is a result of significantly higher dividends from higher output. Afterwards it starts to decline toward its lower steady-state value. Investment is accordingly higher than before -- although as a ratio to output it remains at the level of the LCFE economy.

Real wages also exhibit interesting dynamics. In period 2 they fall below the (low) value of period 1 -- a result of backward indexation as inflation falls in period 1. After period 2, real wage increases in response to higher employment push wage levels asymptotically toward higher steady-state values.

Concerning the simulation results for temporary shocks in a Keynesian (LCUN) economy, the main point to be emphasized is related to the cyclical behavior of output. Aggregate demand, and hence output, rise much more during the four periods of foreign transfers, and then decline to lower levels than in the preceding full-employment economies. We conclude that, like liquidity constraints under temporary transfer shocks, wage rigidity intensifies the amplitude of the adjustment cycle to both temporary and permanent transfer shocks.

4.3 A Permanent Oil Price Windfall

We analyze now the dynamic response to a permanent decline in the price of intermediate imports. This can be interpreted as an oil price fall in an oil-importing economy. The shock has been normalized again to a first-round gain (or direct effect) of 4% of output, reflecting a 40% drop in the international price of intermediate imports (pmr declines from 1.0 to 0.6). Figures 11-15 report the dynamic trajectories of the main macroeconomic variables in response to a permanent oil price windfall, for each of the three economies.

While the first-round magnitude is similar to that of the foreign transfer analyzed above, a lower pmr entails a production substitution effect in addition to the transfer's income effect. That is, even before considering second-round income and substitution effects stemming from induced real exchange rate changes, a lower pmr encourages the substitution of capital and labor by cheaper oil.

Again consider first the NC economy (represented by continuous lines in Figs. 11-15). Consumer wealth and consumption levels (fig. 11) exhibit a dynamic pattern which is qualitatively similar to that in response to a transfer shock: a strong first-period increase and subsequently a gradual and asymptotic convergence to higher long-run levels. Wealth rises by a similar amount than under the transfer shock. But private consumption increases by much less (long-run consumption as a share of output is now 58.7% instead of 62.1% before), due to a strong <u>increase</u> in the private consumption deflator, caused in turn by the real exchange rate depreciation.

Output grows much more than under the foreign transfer shock. The impact effect on output is now 5.4% (as compared to 1.1% before), and long-run output is 6.8% higher (as compared to 2.8% under the transfer shock). This significantly higher output level reflects the massive incentive to change the input mix away from value added and toward intermediate imports, in response to the lower international price of the latter. The strong supply expansion causes a 3.5% initial real exchange rate <u>depreciation</u>, which stands in contrast to the initial <u>appreciation</u> under a foreign transfer shock. In the long run the real exchange rate depreciates by 5.4%, while it had appreciated by 7.4% under the transfer shock. Long-run intermediate imports grow now by a massive 69%, a result of a positive substitution effect (a significantly lower international oil price slightly dampened by the moderate real exchange rate depreciation) and a positive scale effect; by comparison, they rose only 11% under the transfer shock, resulting from a more modest scale effect and a substitution effect stemming only from the real exchange rate appreciation. The significant substitution effects -- in both cases -- reflect the high (unitary) elasticity of substitution between imports and value added, embodied by the Cobb-Douglas production technology.

The real interest rate behaves in a similar way as under the transfer shock because of gradual real exchange depreciation along the transition path. Tobin's q (in units of output) gets a boost in the first period, stemming from the rise in dividends (due to the lower price of intermediate imports), which more than offsets the negative influence of a slightly higher real interest rate. However, investment goods are now dearer due to the real exchange rate depreciation. Hence aggregate investment (which depends on the ratio of q and the price of investment goods) rises in period 1 by only a moderate amount. The long-run capital/output ratio is now 2.94, lower than in the initial steady state, as a result of the real exchange rate depreciation; by contrast, under the foreign transfer shock it had risen to 3.09, helped by the real exchange rate appreciation. Therefore the new long-run investment ratio to output must be lower under the oil windfall; in fact, it declines to 20.6%.

Inflation presents a similar pattern as before. The difference lies in the magnitude of the period-1 inflation decline. The high output expansion under the oil windfall boosts money demand and therefore requires a one-period <u>deflation</u> of 3.4%, which contrasts to the slight but still positive inflation caused by the transfer shock.

The current account behavior replicates the interesting result that a favorable external shock causes a transitory <u>deficit</u>, due to the combination of investment adjustment costs (which cause a gradual capacity expansion) and forward-looking consumers (who anticipate higher future income levels and therefore raise their current spending).

Finally, short and long-term real wages are boosted by higher output levels. The long-run real wage increases in the same proportion as output (6.8%), exceeding significantly the 2.8% rise observed under the foreign transfer shock.

The full-employment economy with liquidity constraints (the LCFE case, depicted by dashed lines in Figs. 11-15) displays a pattern very similar to that of the fully neoclassical case. The chief difference is that liquidity-constrained consumers do not initially adjust their consumption in anticipaton of future output gains. As a result, the current account deficit is now smaller, allowing for additional asset accumulation, which in the long-run leads to higher wealth and sustains an increased consumption/output ratio.

The Keynesian benchmark (represented by the dotted lines in Figs. 11-15) yields richer dynamics. Private wealth shows a much more pronounced transitory hump, which reflects the underlying humps in employment (which boosts human wealth), the real exchange rate (which raises the domestic-currency value of privately-held foreign assets), and the price of equity (q). Consumption as a share of (higher) output follows a path which is similar to the LCFE economy.

The short-term real exchange rate depreciation exceeds significantly the levels reached under the full-employment economies. The reason is a significant transitory output expansion made possible by over-employment in response to sluggish real wage adjustment. Real output reaches a peak in period 2, with a level which is 9.0% higher than in the initial steady state and also exceeds significantly the 5.6% increase in the full-employment economies. Subsequent catch-up of real wages reduces output (which reaches a local minimum of 1.066 in period 10) until convergence to its new long-run equilibrium of 1.069. The real exchange rate mimics the cyclical pattern of output.

The swings in the real interest rate -- in contrast with its relative flatness in the full-employment economies -- reflect the period-2 real exchange rate depreciation and subsequent appreciations (until period 10) and depreciations (thereafter). This causes quite significant short-term fluctuations of the interest rate, from a peak of 7.6% at period 1 to a trough of 5.5% at period 3. Investment as a share of output, affected by countervailing influences of the price of equity, the real exchange rate, and operational profits, shows a similar behavior as in the LCFE economy.

Inflation, which mimics the cycle of output growth, reaches the most negative value across shock categories and economy types in period 1, when the massive income growth requires a 5% deflation to balance the money market. Note that from period 3 to 10 inflation slightly exceeds its long-term equilibrium value of 2%, a result of declining output.

Finally, the dynamic pattern of the real wage and employment under a permanent shock is similar to that of the Keynesian benchmark benefitted by a permanent external transfer. The real wage, determined by backward nominal indexation, reaches a rough in period 2, reflecting the preceding period 1's price deflation. Afterwards it catches up fast to converge toward its higher long-run value. Employment reflects the pattern of real wages, reaching an all-time high of 5.4% over-employment in period 2, subsequently returning asymptotically to full employment. Average over-employment is 3.8% during periods 1 to 5, exceeding significantly the corresponding average of 1.7% in the Keynesian economy affected by a permanent transfer shock. As in the case of the transfer shock, we conclude that wage rigidity intensifies the amplitude of the cyclical response to an oil price shock.

In concluding, the main difference between the oil price windfall and the permanent transfer is that the former involves both a favorable supply shock which boosts production directly and depreciates the real exchange rate, while a foreign transfer implies an income effect which boosts aggregate demand and appreciates the real exchange rate, with an indirect induced effect on supply. Most other variables behave in a qualitatively similar fashion under both shocks, although the quantitative response is significantly more intense under the oil price windfall.

5. CONCLUDING REMARKS

This paper has developed a dynamic macroeconomic general equilibrium model for three economies: a neoclassical case with frictionless, instantaneous clearing in goods, assets and labor markets, a full-employment economy with groups of liquidity-constrained consumers and investors, and a Keynesian benchmark with liquidity-constrained agents and wage rigidity giving rise to temporary deviations from full employment.

The model has been applied to simulate the impact, transitional, and steady-state effects of permanent, temporary unanticipated, and temporary anticipated external shocks. Two shocks have been considered: a higher foreign transfer and a lower international price of intermediate imports.

The simulations demonstrate the usefulness of a consistent framework based on first principles for tracing out and understanding the macroeconomic response to disturbances. The numerical exercises illustrate three main points. First, due to the import content of production in the model, both permanent and transitory external shocks lead to long-run changes in productive capacity and real output, as well as in the other endogenous variables. Second, when favorable permanent shocks lead to higher steady-state capital and output (as is the case in the simulations above), their short-run effect is to cause a current account deterioration. The reason is that consumption of unconstrained consumers immediately rises in response not only to current, but also to anticipated future real income gains, and the latter accrue only gradually due to the existence of investment adjustment costs. This is in sharp contrast with the effect of favorable transitory shocks, which unambiguously improve the current account while they last. Third, market imperfections have important consequences for the dynamic response of the economy to exogenous disturbances. In contrast with the smooth, monotonic adjustment pattern displayed by the neoclassical benchmark economy in the simulations above, liquidity constraints or wage rigidity tend to amplify the cyclical response to external shocks. This suggests that market imperfections could be a major factor behind the complex dynamic adjustment patterns observed in actual economies.

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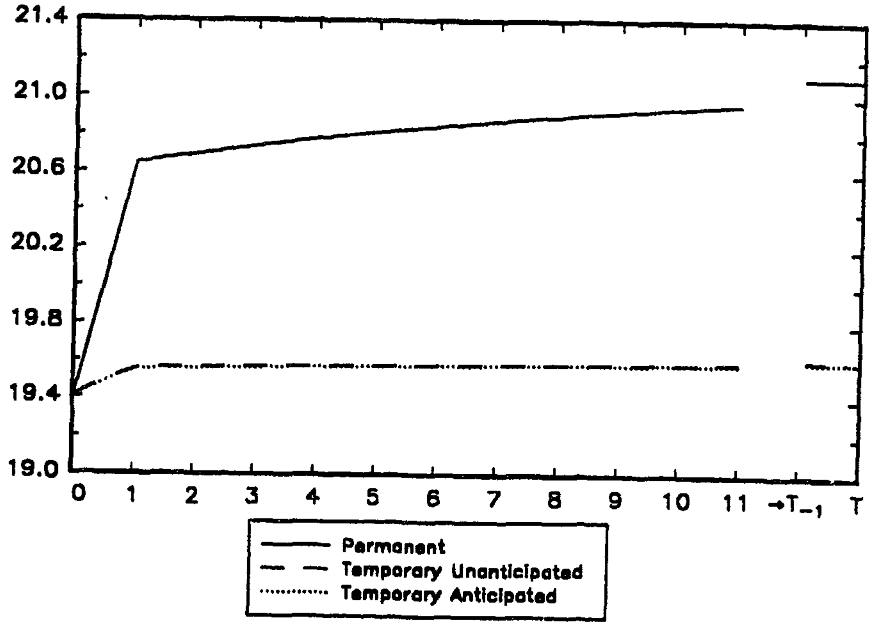
Figure 1

Foreign Transfer Shock – Total Wealth

Neoclassical Economy



Non–Neoclassical Economies

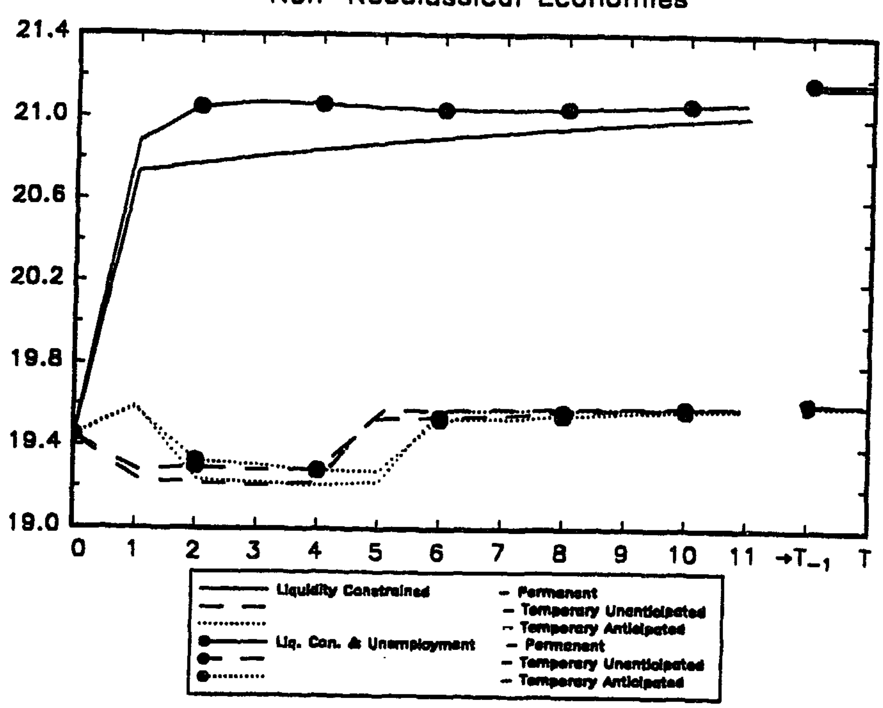
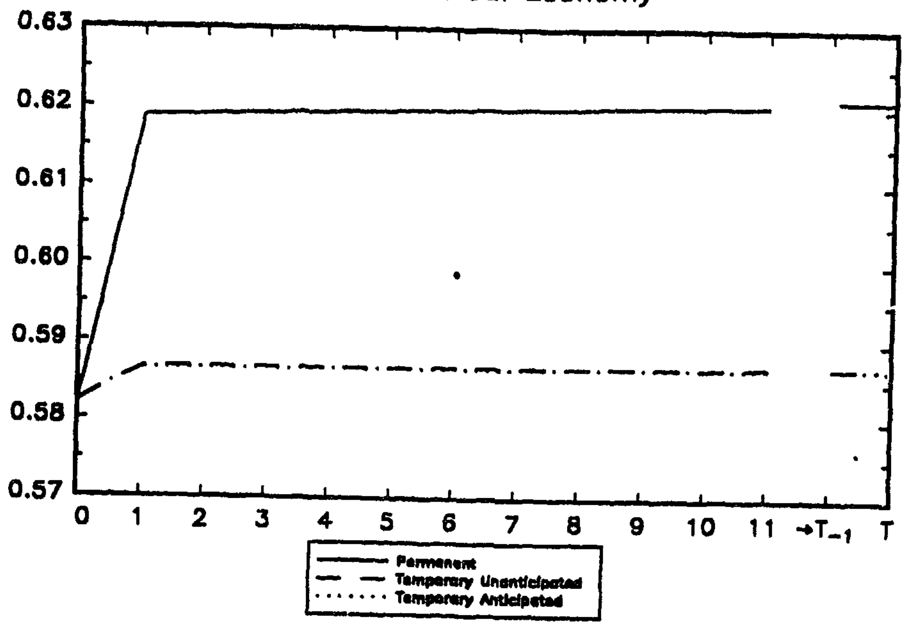


Figure 2

Foreign Transfer Shock – Private Consumption / Output

Neoclassical Economy



Non–Neoclassical Economies

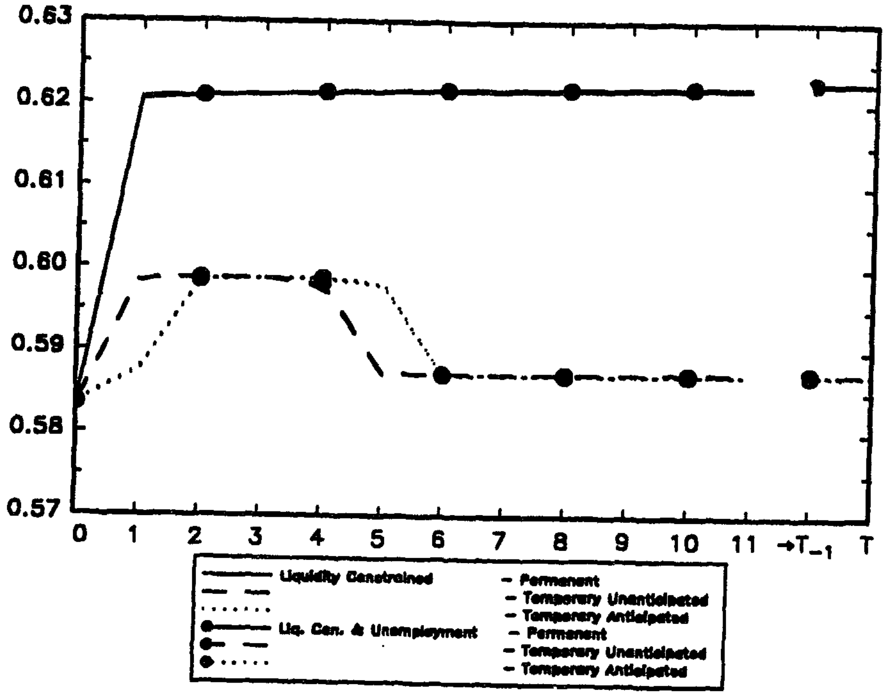
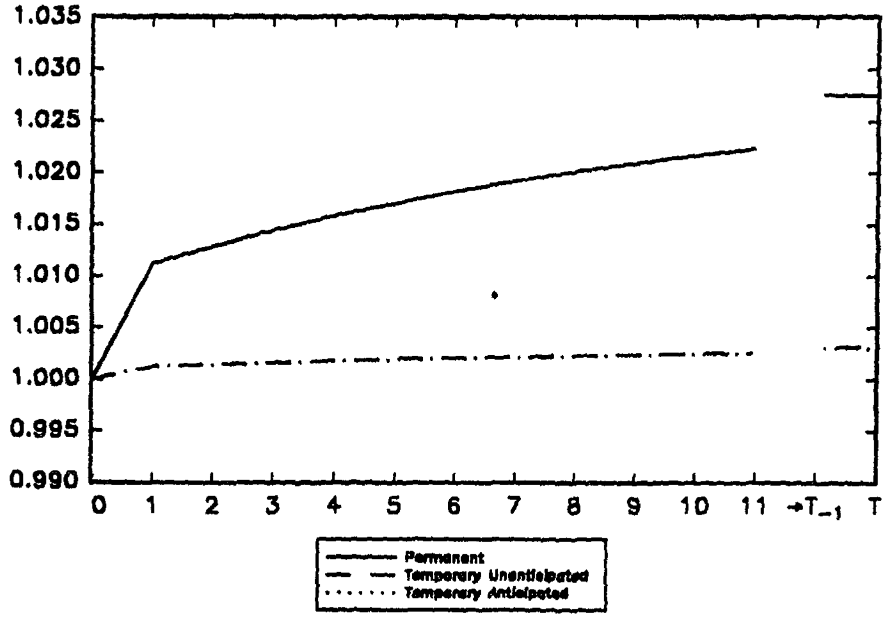


Figure 3

Foreign Transfer Shock – Output

Neoclassical Economy



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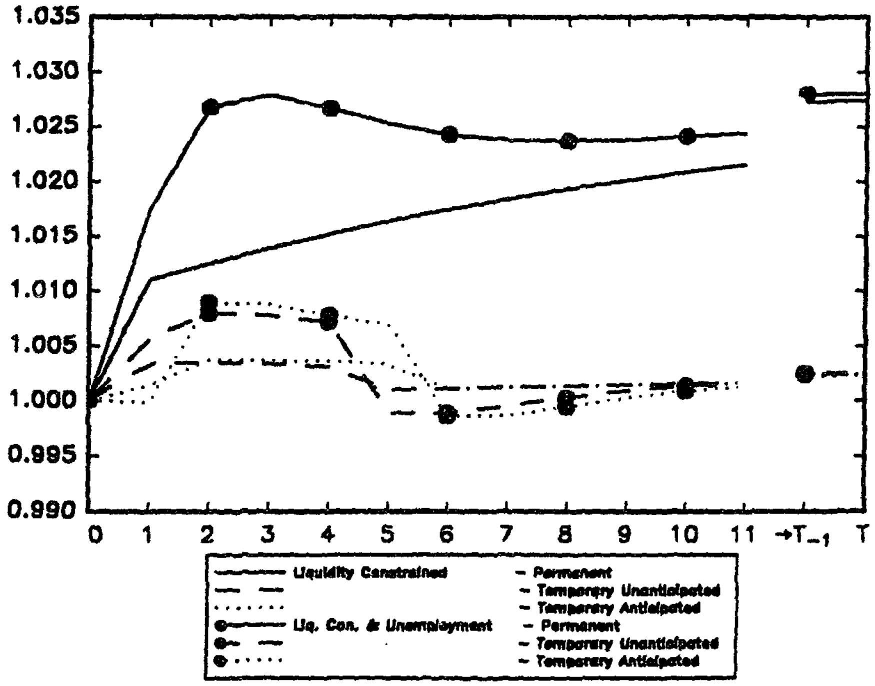
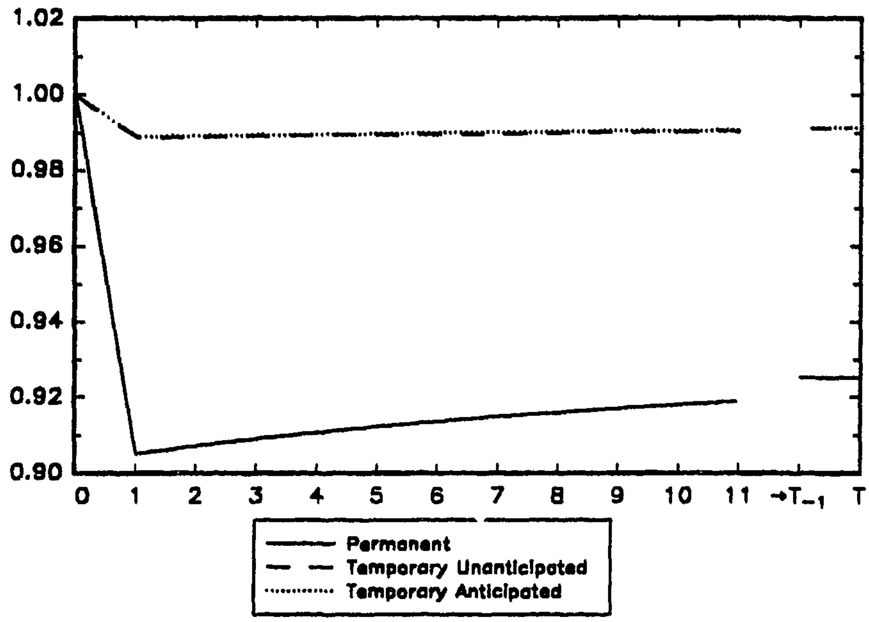


Figure 4

Foreign Transfer Shock — Real Exchange Rate

Neoclassical Economy



Non—Neoclassical Economies

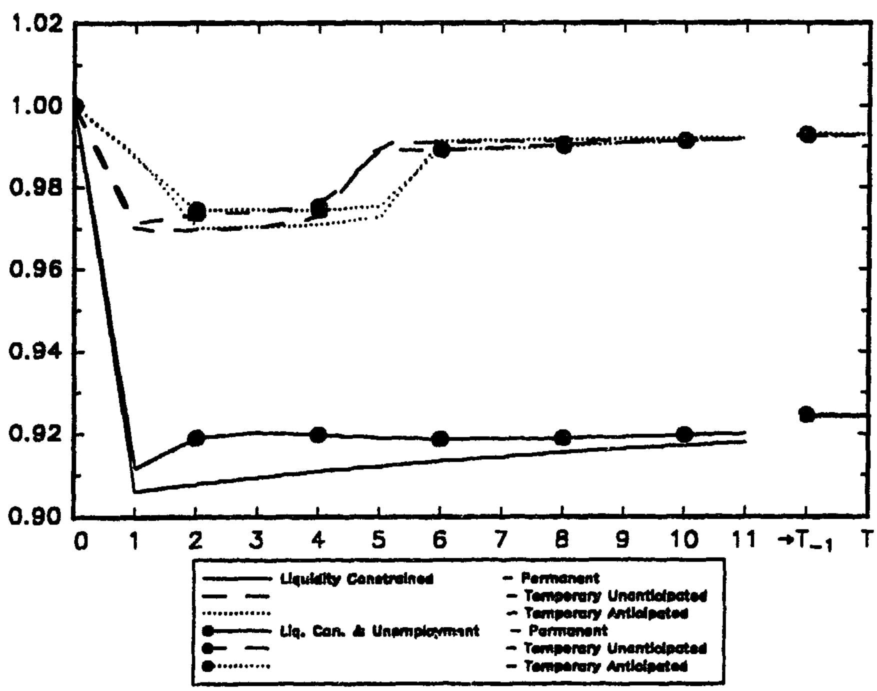
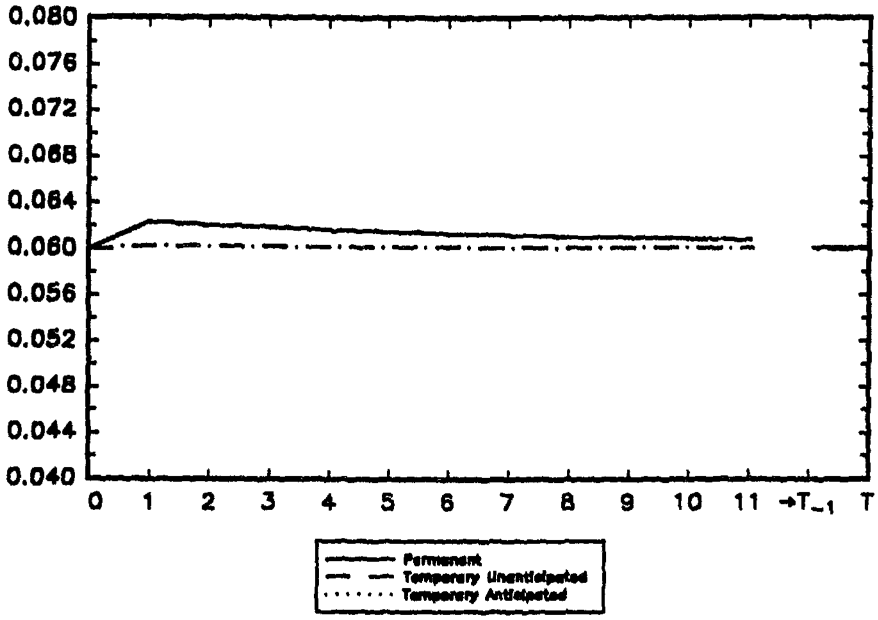


Figure 5

Foreign Transfer Shock — Real Interest Rate

Neoclassical Economy



Non–Neoclassical Economies

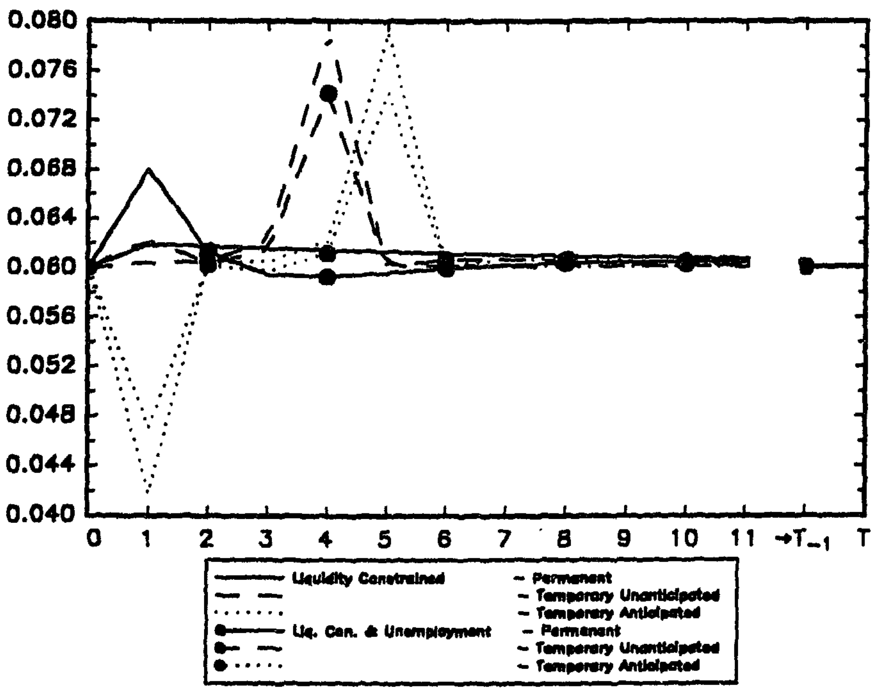
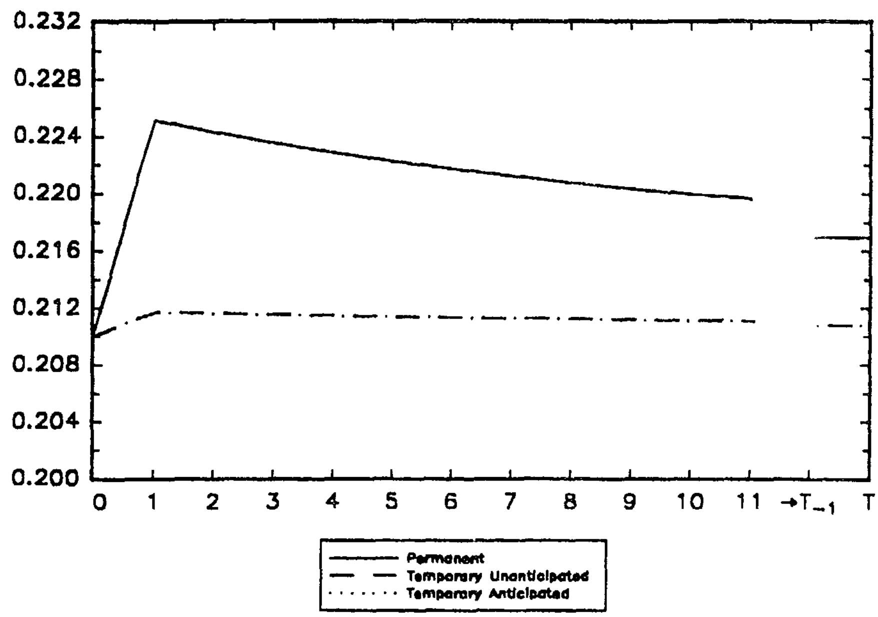


Figure 6

Foreign Transfer Shock – Private Investment / Output

Neoclassical Economy



Non–Neoclassical Economies

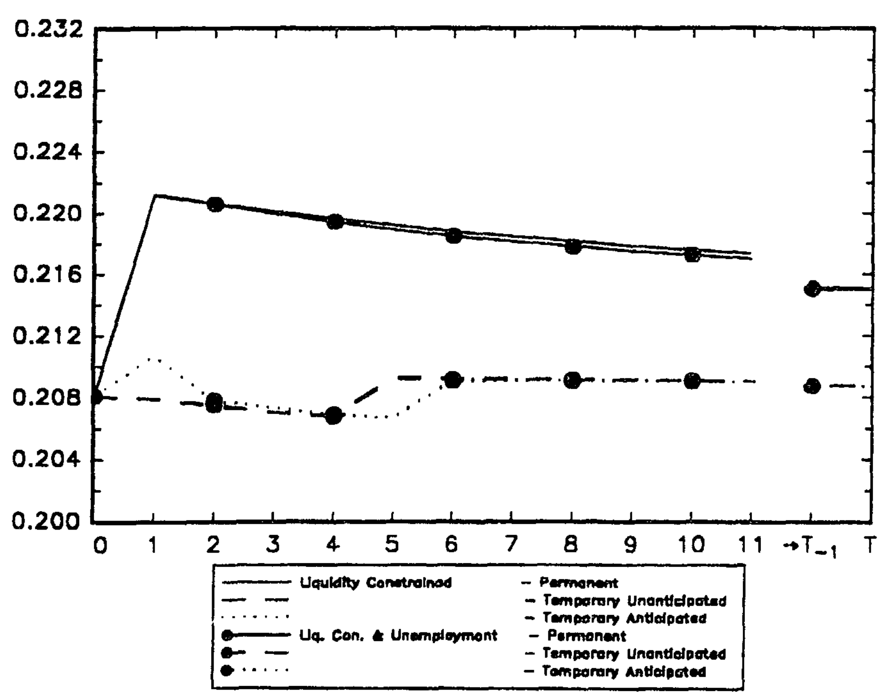


Figure 7

Foreign Transfer Shock – Inflation

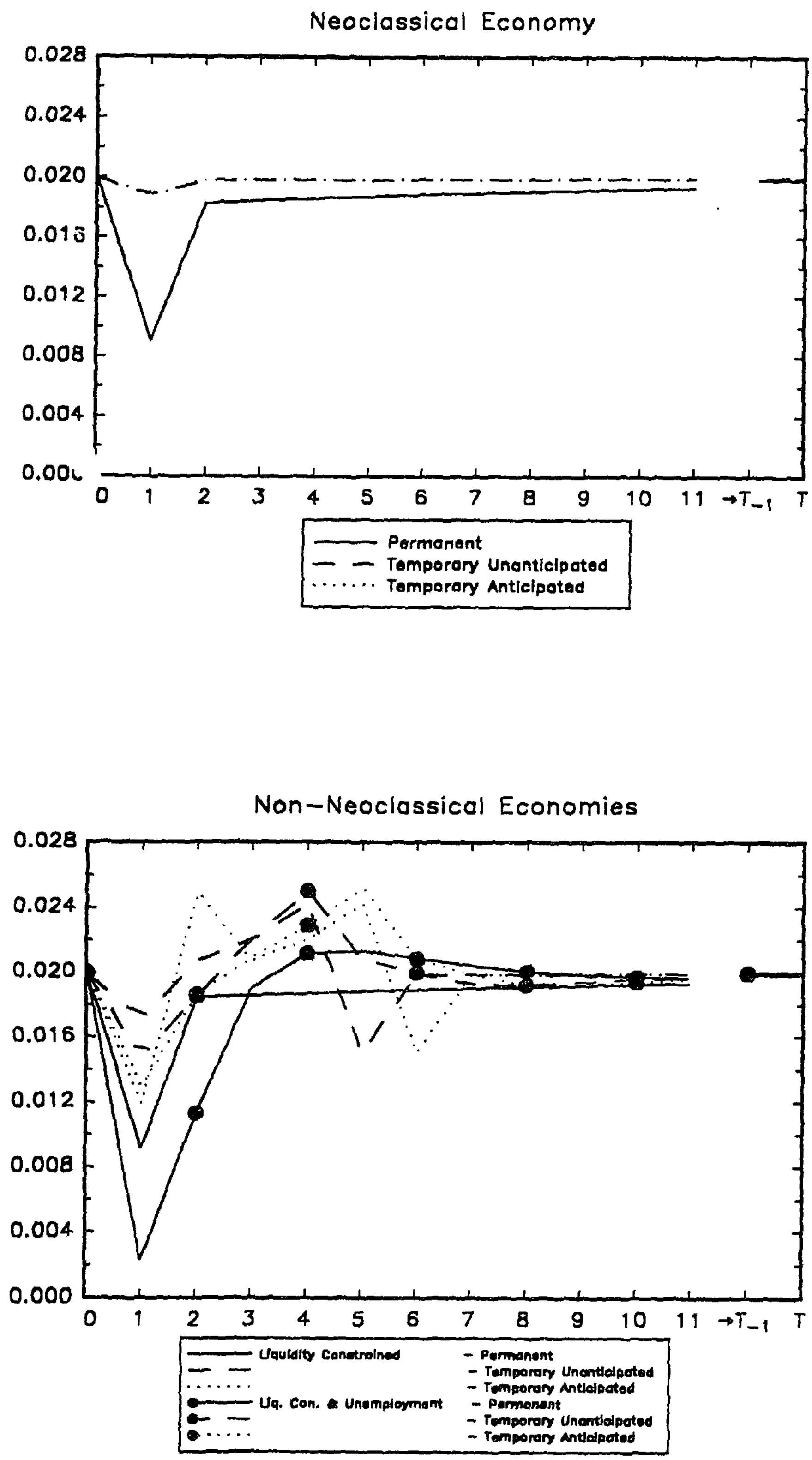
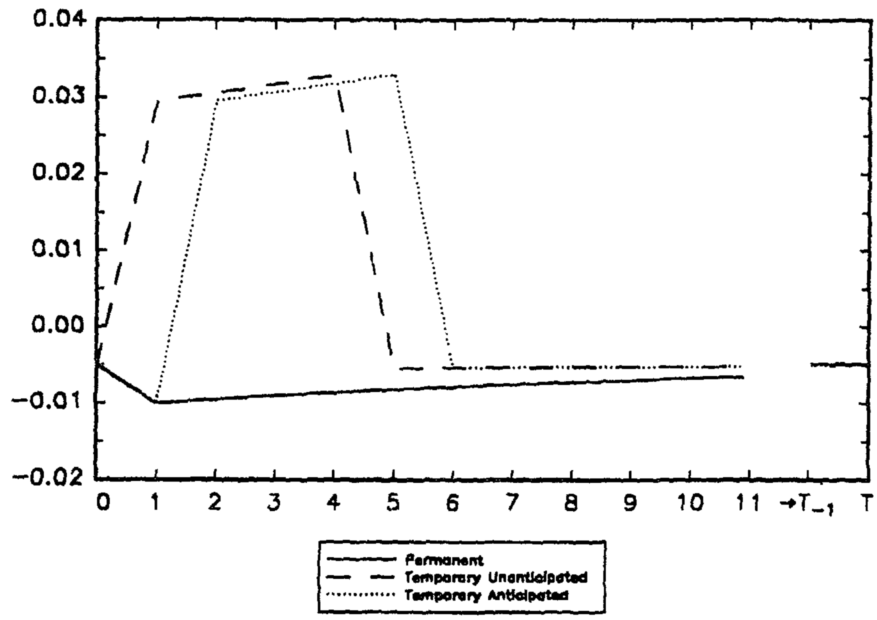


Figure 8

Foreign Transfer Shock – Current Account / Output

Neoclassical Economy



Non–Neoclassical Economies

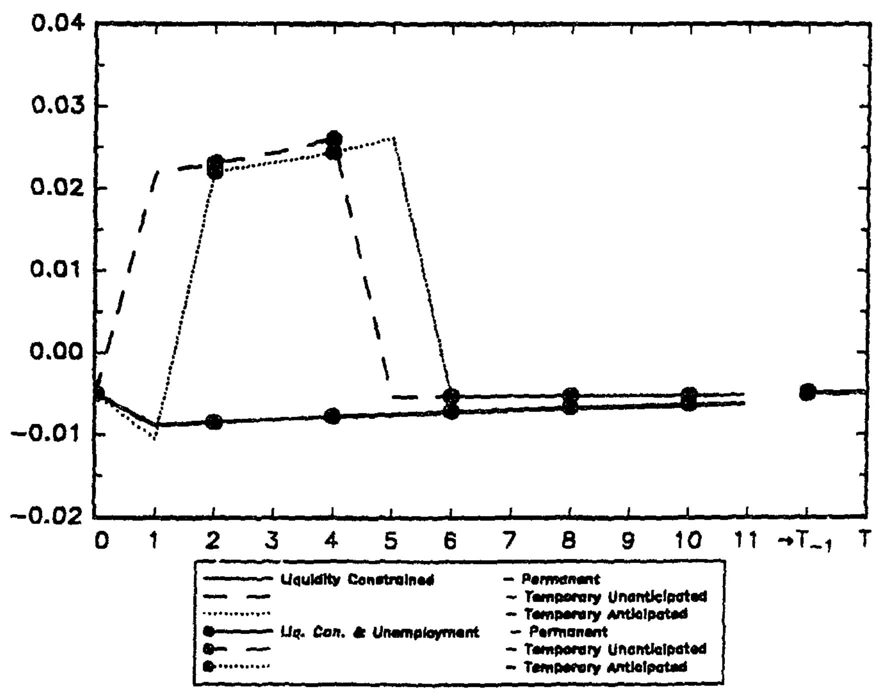
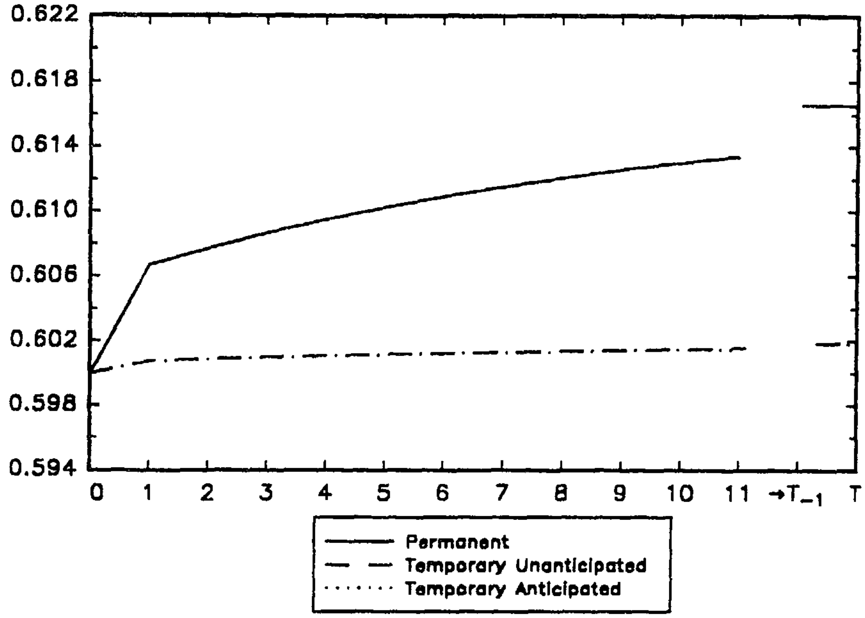


Figure 9

Foreign Transfer Shock — Real Wage

Neoclassical Economy



Non–Neoclassical Economies

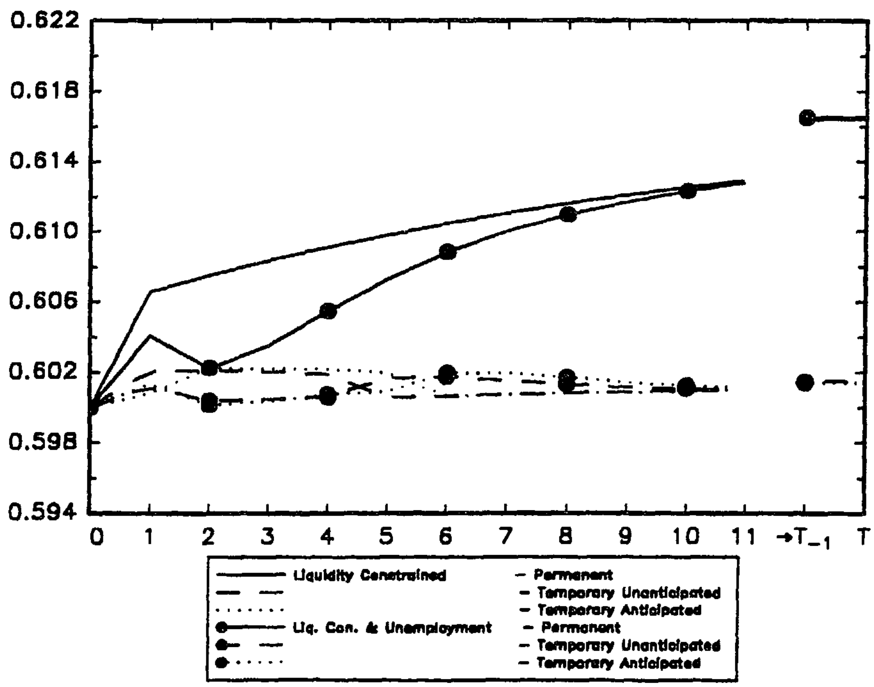


Figure 10

Foreign Transfer Shock — Employment

All Economies

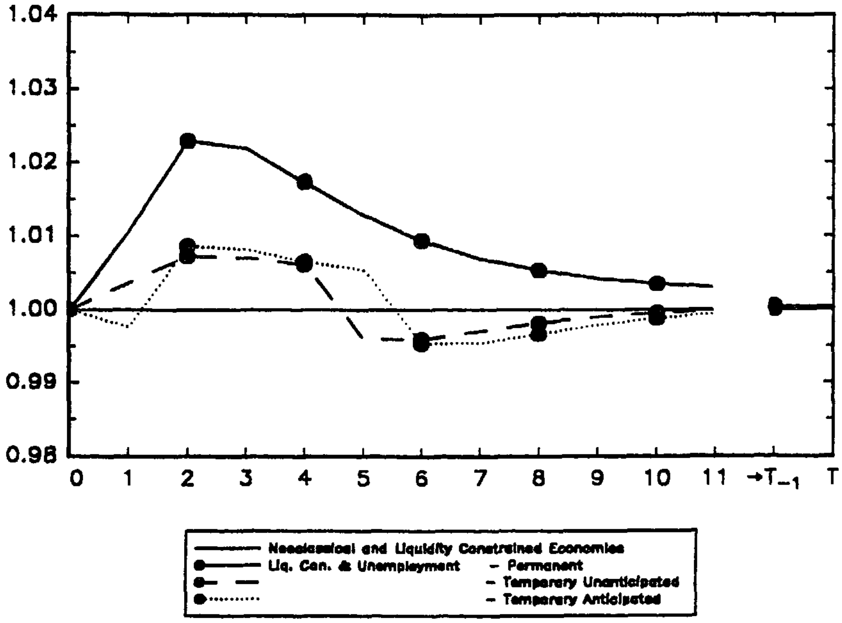
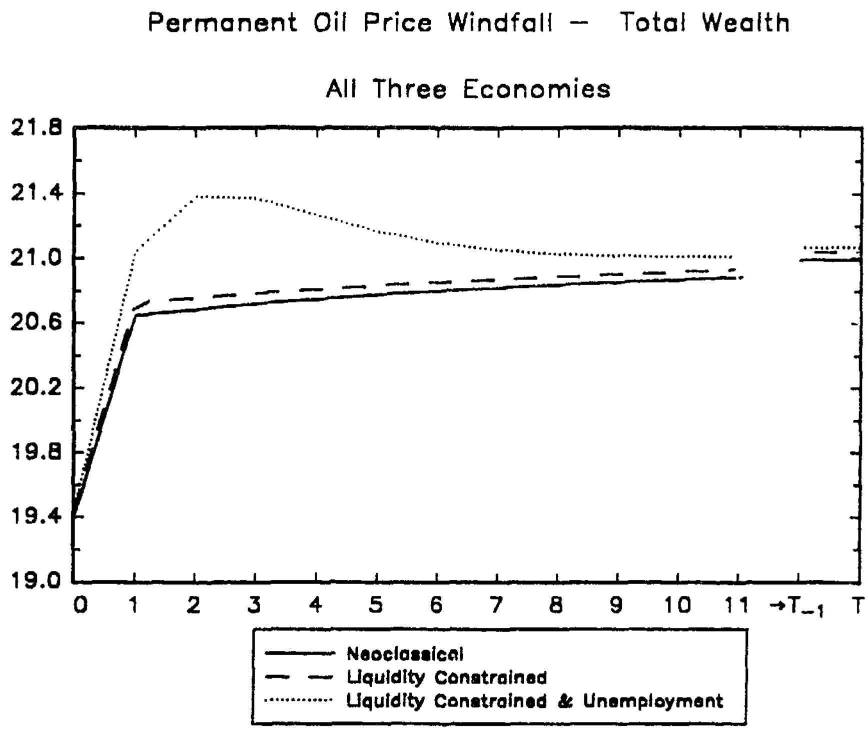


Figure 11


Permanent Oil Price Windfall — Total Wealth
All Three Economies
21.8
21.4
21.0
20.6
20.2
19.8
19.4
19.0
0 1 2 3 4 5 6 7 8 9 10 11 →T₋₁ T
Neoclassical
Liquidity Constrained
Liquidity Constrained & Unemployment

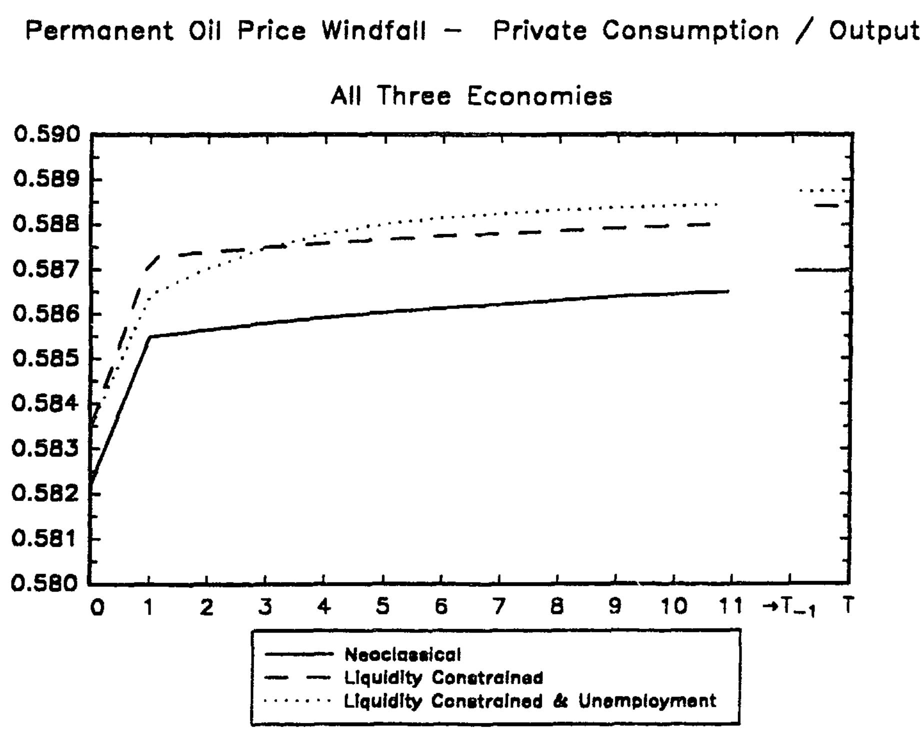
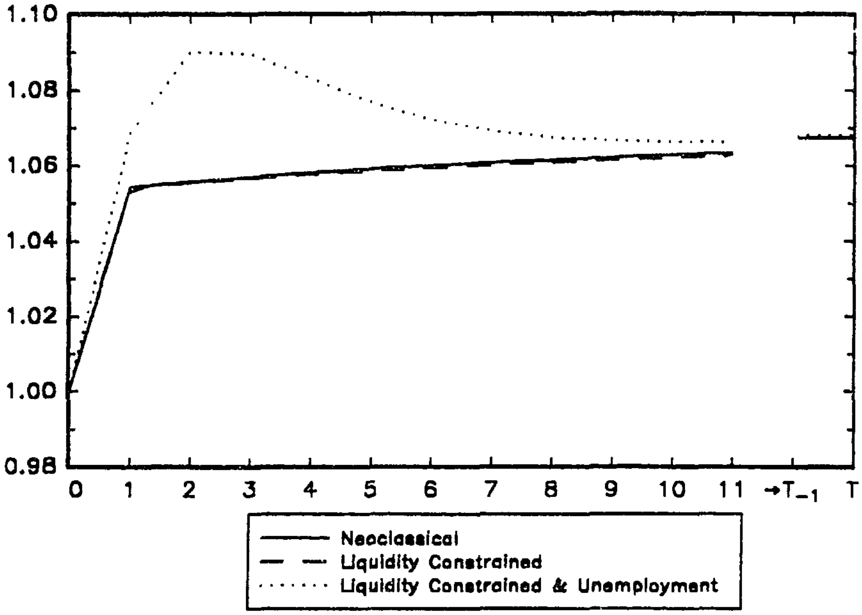

Permanent Oil Price Windfall — Private Consumption / Output
All Three Economies
0.590
0.589
0.588
0.587
0.586
0.585
0.584
0.583
0.582
0.581
0.580
0 1 2 3 4 5 6 7 8 9 10 11 →T₋₁ T
Neoclassical
Liquidity Constrained
Liquidity Constrained & Unemployment

Figure 12

Permanent Oil Price Price Windfall — Output

All Three Economies



Permanent Oil Price Windfall — Real Exchange Rate

All Three Economies

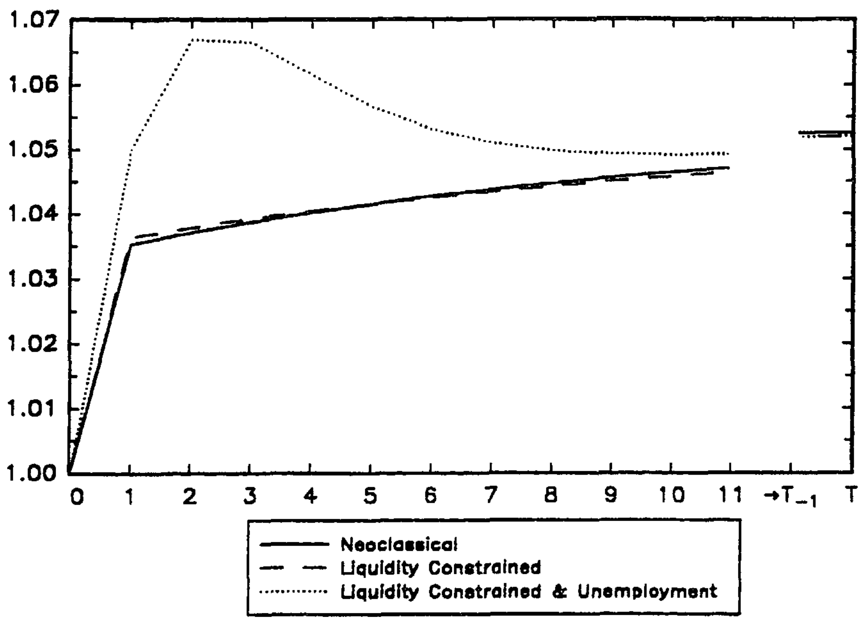
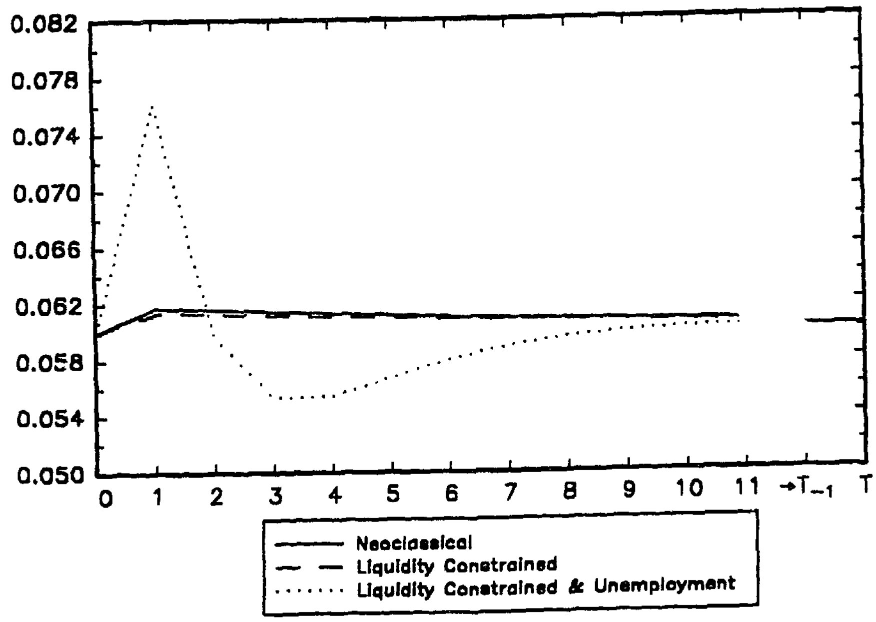


Figure 13

Permanent Oil Price Windfall — Real Interest Rate

All Three Economies



Permanent Oil Price Windfall — Private Investment / Output

All Three Economies

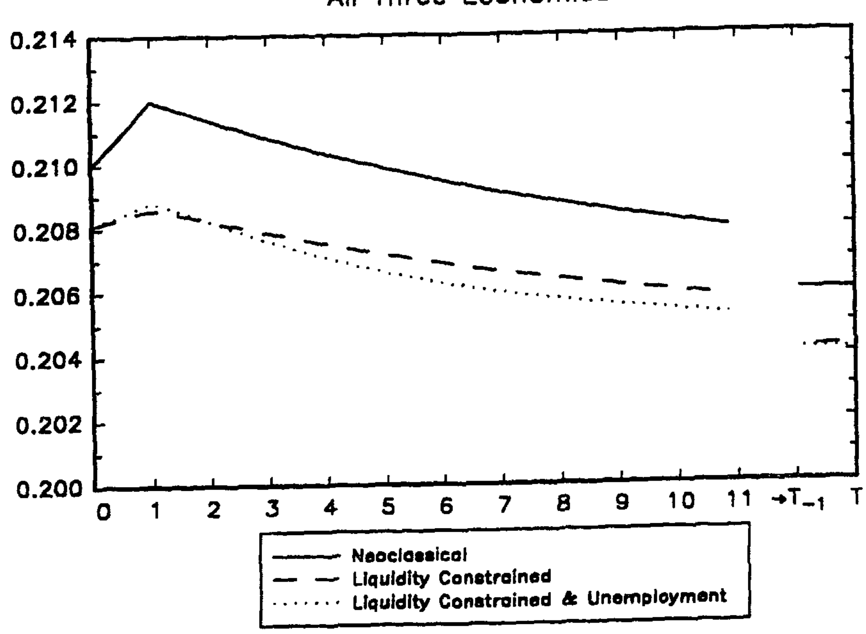
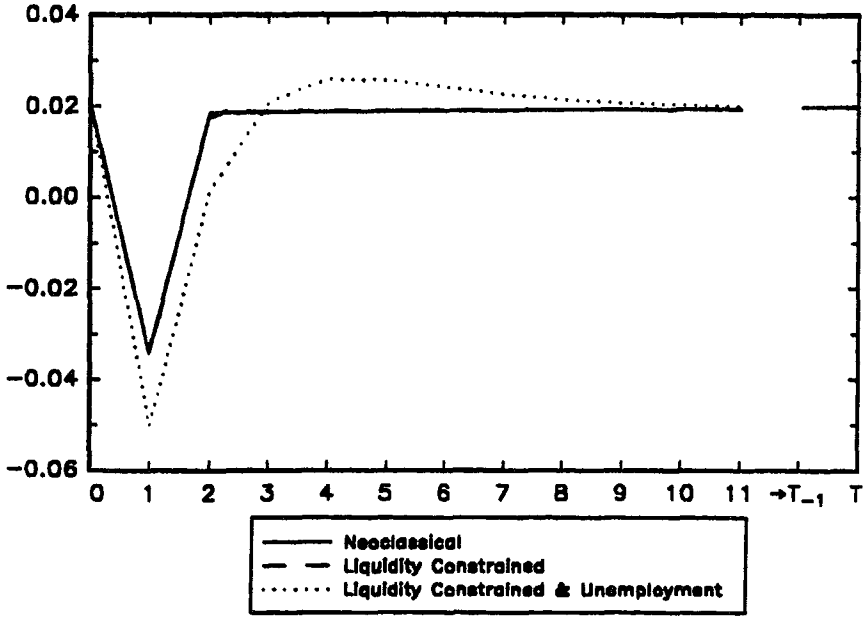


Figure 14

Permanent Oil Price Windfall — Inflation

All Three Economies



Permanent Oil Price Windfall — Current Account / Output

All Three Economies

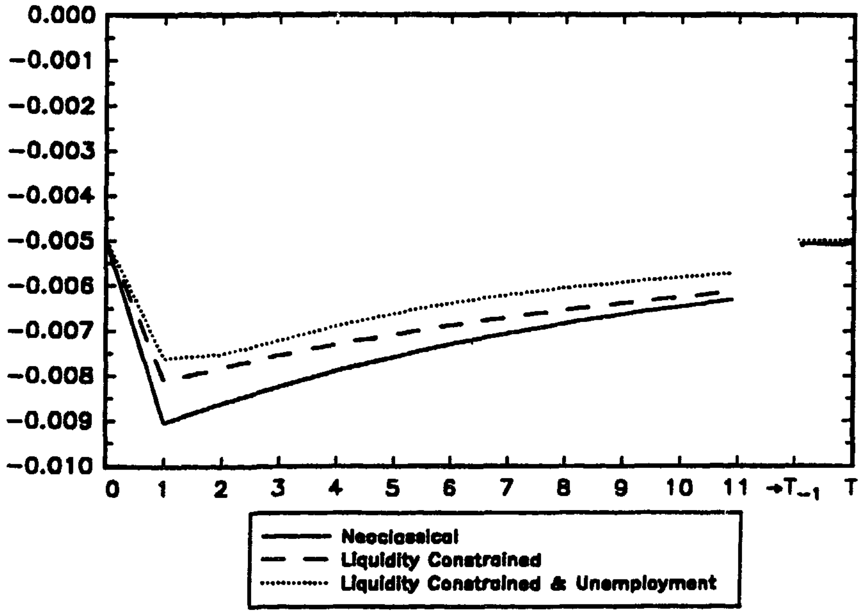
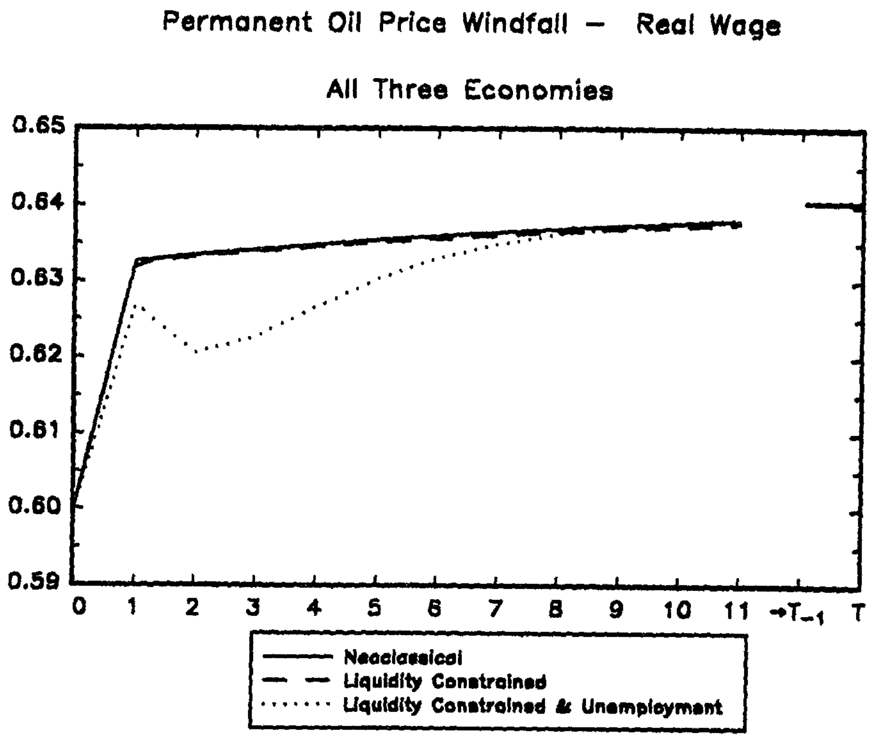
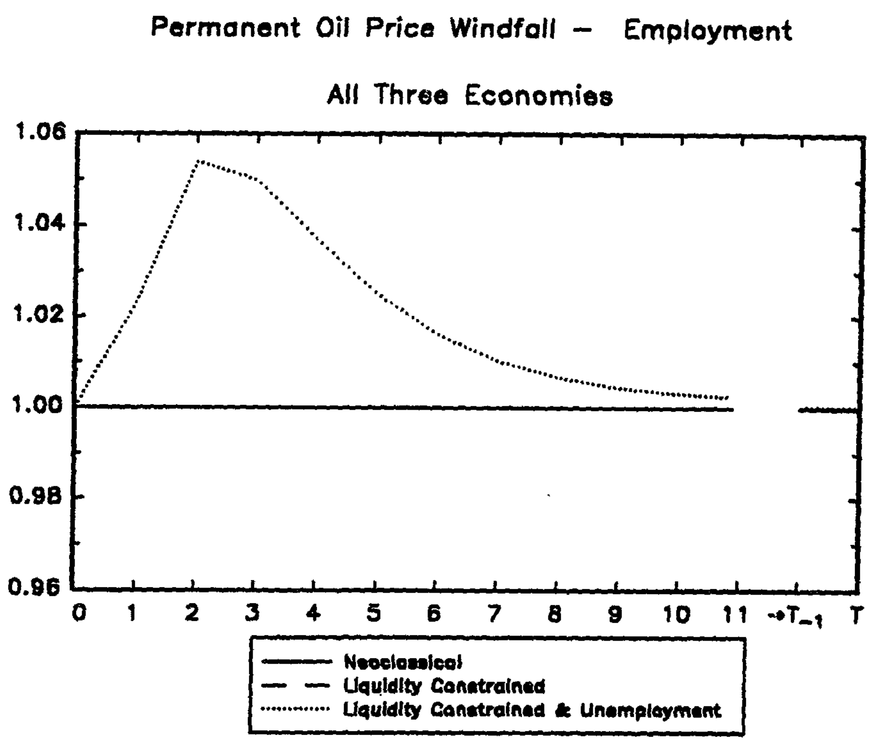


Figure 15


Permanent Oil Price Windfall — Real Wage
All Three Economies
0.65
0.64
0.63
0.62
0.61
0.60
0.59
0 1 2 3 4 5 6 7 8 9 10 11 →T₋₁ T
Neoclassical
Liquidity Constrained
Liquidity Constrained & Unemployment


Permanent Oil Price Windfall — Employment
All Three Economies
1.06
1.04
1.02
1.00
0.98
0.96
0 1 2 3 4 5 6 7 8 9 10 11 →T₋₁ T
Neoclassical
Liquidity Constrained
Liquidity Constrained & Unemployment

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